REPORT OF THE PROCEEDINGS

OF THE

Forty-first Annual Convention

OF THE

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

(INCORPORATED)

HELD AT

ATLANTIC CITY, N. J.,

June 22, 23 and 24, 1908.

CHICAGO:
THE HENRY O. SHEPARD COMPANY,
120-130 SHERMAN STREET,
1908.

OFFICERS FOR 1908-1909.

ELECTED AT THE CLOSE OF CONVENTION OF 1908.

PRESIDENT.

H. H. VAUGHAN, Asst. to Vice-Prest., Canadian Pacific Ry., Montreal, Can.

FIRST VICE-PRESIDENT.

G. W. WILDIN, M. S., N. Y. N. H. & H. R. R., New Haven, Conn.

SECOND VICE-PRESIDENT.

C. E. FULLER, S. M. P. & M., Union Pacific R. R., Omaha, Neb.

THIRD VICE-PRESIDENT.

J. E. MUHLFELD, G. S. M. P., B. & O. R. R., Baltimore, Md.

TREASURER.

ANGUS SINCLAIR, New York City.

EXECUTIVE MEMBERS.

* C. A. SELEY, M. E., C. R. I. & P. Ry., Chicago, Ill.
* JOHN HOWARD, S. M. P., N. Y. C. & H. R. R. R., New York City.
* F. M. WHYTE, C. M. E., New York Central Lines, New York City.
† H. T. BENTLEY, A. S. M. P., C. & N.-W. Ry., Chicago, Ill.
† T. RUMNEY, M. S., Erie R. R., New York City.
† T. H. CURTIS, S. M., L. & N. R. R., Louisville, Ky.

SECRETARY.

JOS. W. TAYLOR, 390 Old Colony Building, Chicago, Ill.

* Term expires June, 1909.
† Term expires June, 1910.

COMMITTEES SELECTED FOR THE 1909 CONVENTION.

STANDING COMMITTEES.

Mechanical Stokers:

T. RUMNEY (Chairman), M. S., Erie R. R., New York City.
D. F. CRAWFORD, G. S. M. P., Penna. Lines, Pittsburgh, Pa.
C. E. GOSSETT, M. M., Iowa Central R. R., Marshalltown, Iowa.
F. H. CLARK, G. S. M. P., C. B. & Q. R. R., Chicago, Ill.
GEO. HODGINS, 114 Liberty street, New York City.

SPECIAL COMMITTEES.

1.—Revision of Standards:

W. H. V. ROSING (Chairman), M. E., Mo. Pacific Ry., St. Louis, Mo.
T. W. DEMAREST, S. M. P., Penna. Lines, Ft. Wayne, Ind.
C. B. YOUNG, M. E., C. B. & Q. R. R., Chicago, Ill.
E. T. WHITE, S. M. P., B. & O. R. R., Baltimore, Md.
G. W. WILDIN, M. S., N. Y. N. H. & H. R. R., New Haven, Conn.

2.—Motor Cars:

J. E. MUHLFELD (Chairman), G. S. M. P., B. & O. R. R., Baltimore, Md.
R. N. DURBOROW, S. M. P., Penna. R. R., Altoona, Pa.
C. E. FULLER, S. M. P. & M., Union Pacific R. R., Omaha, Neb.
A. W. HORSEY, M. E., Can. Pac. Ry., Montreal, Can.
J. H. MANNING, S. M. P., D. & H. Co., Albany, N. Y.

3.—Castle Nuts:

R. B. KENDIG (Chairman), M. E., L. S. & M. S. Ry., Cleveland, Ohio.
J. F. DE VOY, M. E., C. M. & St. P. Ry., West Milwaukee, Wis.
G. S. EDMONDS, M. M., D. & H. Co., Oneonta, N. Y.
J. N. MOWERY, M. E., L. V. R. R., South Bethlehem, Pa.
JNO. PLAYER, Amer. Loco. Co., Dunkirk, N. Y.
W. L. AUSTIN, Baldwin Loco. Works, Philadelphia, Pa.
H. P. MEREDITH, A. E. M. P., Penna. R. R., Altoona, Pa.

4.—Safety Valves:

F. M. GILBERT (Chairman), M. E., N. Y. C. & H. R. R. R., New York City.

JAS. MILLIKEN, S. M. P., P. B. & W. R. R., Wilmington, Del.

W. D. ROBB, S. M. P., Grand Trunk Ry., Montreal, Can.

M. H. WICKHORST, Engr. Tests, C. B. & Q. R. R., Aurora, Ill.

J. G. NEUFFER, S. M., Illinois Central R. R., Chicago, Ill.

5.—Superheaters:

LE GRAND PARISH (Chairman), S. M. P., L. S. & M. S. Ry., Cleveland, Ohio.

GRANT HALL, S. M. P., Can. Pac. Ry., Winnipeg, Man.

R. D. HAWKINS, M. E., Great Northern Ry., St. Paul, Minn.

W. F. BUCK, S. M. P., A. T. & S. F. Ry., Chicago, Ill.

C. A. SELEY, M. E., C. R. I. & P. Ry., Chicago, Ill.

6.—Widening Gauge on Curves:

F. M. WHYTE (Chairman), C. M. E., New York Central Lines, New York.

W. H. LEWIS, S. M. P., N. & W. R. R., Roanoke, Va.

F. C. CLEAVER, S. M. P., Rutland R. R., Rutland, Vt.

7.—Steel Tires:

A. W. GIBBS (Chairman), G. S. M. P., Penna. R. R., Altoona, Pa.

A. STEWART, G. S. M. P., Southern Ry., Washington, D. C.

WM. MOIR, S. M. P., Northern Pacific Ry., St. Paul, Minn.

H. J. SMALL, G. S. M. P., Southern Pacific Co., San Francisco, Cal.

G. O. HAMMOND, M. E., Erie R. R., Meadville, Pa.

8.—Tender Trucks:

H. T. BENTLEY (Chairman), A. S. M. P., C. & N.-W. Ry., Chicago, Ill.

JOHN HAIR, S. M. P., B. & O. S.-W. Ry., Cincinnati, Ohio.

A. E. MANCHESTER, S. M. P., C. M. & St. P. Ry., West Milwaukee, Wis.

J. F. WALSH, S. M. P., C. & O. Ry., Richmond, Va.

T. H. CURTIS, S. M., L. & N. R. R., Louisville, Ky.

9.—Fuel Economies:

W. C. HAYES (Chairman), S. L. O., Erie R. R., New York.
R. P. C. SANDERSON, S. M. P., Virginian Ry., Norfolk, Va.
D. R. MacBAIN, A. S. M. P., N. Y. C. & H. R. R. R., Albany, N. Y.
T. B. PURVES, JR., S. M. P., D. & R. G. R. R., Denver, Colo.
W. H. WILSON, S. M. P., B. R. & P. Ry., Du Bois, Pa.

10.—Lubricating Material Economies:

T. S. LLOYD (Chairman), S. M. P., D. L. & W. R. R., Scranton, Pa.
E. D. BRONNER, S. M. P., Michigan Central R. R., Detroit, Mich.
E. F. NEEDHAM, S. L. & C. D., Wabash Ry., Springfield, Ill.
T. ROOPE, S. M. P., C. B. & Q. R. R., Lincoln, Neb.
G. J. De VILBISS, S. M. P., Hocking Valley Ry., Columbus, Ohio.

11.—Revision of Constitution and By-Laws:

D. F. CRAWFORD (Chairman), G. S. M. P., Penna. Lines, Pittsburgh, Pa.
F. H. CLARK, G. S. M. P., C. B. & Q. R. R., Chicago, Ill.
T. H. CURTIS, S. M., L. & N. R. R., Louisville, Ky.

12.—Subjects:

ROBERT QUAYLE (Chairman), S. M. P., C. & N.-W. Ry., Chicago, Ill.
WM. McINTOSH, S. M. P., C. R. R. of N. J., Jersey City, N. J.
P. MAHER, S. M. P., C. & A. R. R., Bloomington, Ill.

13.—Arrangements:

H. H. VAUGHAN.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this Association shall be the "American Railway Master Mechanics' Association."

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this Association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the Association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them:

(1) Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock.

(2) General foremen, if their names are presented by their superior officers.

(3) Two representatives from each locomotive and car building works.

(4) One representative member may be appointed by any railroad company to represent its interests in the Association. Such appointment shall be in writing and shall emanate from the President, General Manager or General Superintendent. Such member shall have all the privileges of an active member, including one vote on all questions, and, in addition thereto, shall, on all measures pertaining to the determination of what tests shall be conducted by the Association or the expenditure of money for conducting same, have one additional vote for each full one hundred engines which are in actual operation or in process of purchase by the road or system which he represents. Such membership shall continue until notice is given the Association of his withdrawal or the appointment of his successor.

SEC. 2. Civil and mechanical engineers, or other persons having such

a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the Association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate, and report to the Executive Committee of the Association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to letter ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. (1) All members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

(2) A representative member shall pay in addition to his personal dues as above, an amount for each additional vote to which he is entitled, as shall be determined each year by the Executive Committee, prorated upon the cost of conducting such tests as may be determined upon at each convention, provided that no such assessment shall exceed $5 per vote per year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this Association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of the Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the Association, active or associate, who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected honorary members. The nominations must be made by the Executive Committee. The dues of the honorary members shall be remitted, and they shall have all the privileges of active members except that of voting.

SEC. 6. Any member who, during the meetings of the Association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the Association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the Association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, a Secretary, and six Executive members, the six Executive members with the President, Vice-Presidents and Treasurer shall constitute the Executive Committee, and they, with the exception of the Secretary, shall constitute the Executive Committee of the Association.

ARTICLE V.

DUTIES OF OFFICERS.

SECTION 1. It shall be the duty of the President to preside at all the meetings of the Association, appoint all committees — designating the chairman — except as hereinafter provided, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore.*

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the Association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the Association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SECTION 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the Association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to an

amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the Association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report.

SEC. 3. Five members of the Executive Committee shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the annual convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually, intimating the date and place when and where candidates may be examined for the scholarships of the Association in the Stevens Institute of Technology, Hoboken, New Jersey.

Acceptable candidates for the scholarship shall be, first, sons of members or of deceased members of the Association. If there is not a sufficient number of such applicants for the June examination, then applications will be received from other railroad employes or the sons of other railroad employes for the fall examination. The Secretary shall issue a proper circular in this case as before. In extending the privilege outside of the families of members, preference shall be given to employes or the sons of employes, or the sons of deceased employes of the mechanical departments.

Candidates for these scholarships shall apply to the Secretary of this Association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The successful candidate shall be required to take the course of mechanical engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SECTION 1. The officers of the Association, except the Secretary as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections

shall not be postponed. The President, Vice-Presidents and Treasurer shall hold office for one year, and Executive members for two years, or until successors are chosen, provided, however, that three Executive members shall be elected for one year at the time of the adoption of this amendment. Three Executive members shall be elected each year thereafter.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the results.

SEC. 3. A Secretary from among the members of the Association shall be appointed by a majority of the Executive Committee at its first meeting after the annual election, or as soon thereafter as the votes of a majority of the members of the Executive Committee can be secured for a candidate. The term of office of the Secretary thus appointed, unless terminated sooner, shall cease at the first meeting, after the next annual election succeeding his appointment, of the Executive Committee organized for the transaction of business. Two-thirds of the members of the Executive Committee shall have power to remove the Secretary at any time. His compensation, if any, shall be fixed for the time that he holds office by vote of the majority of the Executive Committee. He shall also act as Secretary of the Executive Committee.

ARTICLE IX.

AUDITING COMMITTEE.

SECTION 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the Association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the Association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a commitee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the Association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the Association approved of subjects for investigation, the President shall appoint individuals or special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report

on any subject which a majority of the members present may approve; or individual papers may be presented to the Association after approval by the Executive Committee. Papers and reports shall be presented by abstracts, which shall not occupy more than ten minutes in the reading unless otherwise ordered by the Association.

RECOMMENDATIONS OF STANDARDS.

SEC. 4. Any proposition recommending the adoption of standard construction or practice shall be in writing and be accompanied by drawings, if the latter are necessary for a clear understanding of the subject. Such proposition shall then be submitted to the Association for discussion, after which a vote shall be taken to decide whether the proposition shall be submitted for decision by letter ballot to all the members entitled to vote. If decided in the affirmative, the Secretary, within three months from the time the vote of the Association is taken on such measure, shall send by mail to each member a blank ballot, and a copy of the proposed recommendation, with a report, to be approved by the Executive Committee, of the discussion thereon; such ballot to be filled up, signed and remailed to the Secretary, who will count all the ballots received within thirty days from the date they were sent to the members, and he shall then announce the vote in such manner as the Executive Committee may prescribe. Any recommendation securing two-thirds of the votes cast shall be adopted by the Association.

SEC. 5. All reports, resolutions and recommendations involving the use, or proposed use, by railroad companies, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Association only by the Executive Committee.

ARTICLE X.

AMENDMENTS.

SECTION I. The Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

BY-LAWS.

TIME OF MEETING.

I. The regular meeting of the Association shall be held annually in June of each year.

HOURS OF SESSION.

II. The regular hours of session shall be from 9:30 o'clock A.M. to 1:30 o'clock P.M.

PLACE OF MEETING.

III. The time and place for holding the Annual Convention shall be selected by a Joint Committee composed of the President, three Vice-Presidents and Treasurer of this Association and a corresponding committee from the Master Car Builders' Association. This Joint Committee shall meet within six months after the convention and decide upon the time and place of meeting.

QUORUM.

IV. At any regular meetihg of the Association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this Association shall, unless otherwise ordered by a vote, proceed in the following order:

1. Opening prayer.
2. Address by the President.
3. Acting on the minutes of the last meeting.
4. Reports of Secretary and Treasurer.
5. Assessment and announcement of annual dues.
6. Election of Auditing Committee.
7. Unfinished business.
8. New business.
9. Reports of committees.

10. Reading of papers and discussion of questions propounded by members.
11. Routine and miscellaneous business.
12. Election of officers.
13. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P.M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the Association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken, and no member shall have the floor more than five minutes at a time unless otherwise ordered.

NAMES AND ADDRESSES OF MEMBERS.

Active members are shown in Roman letters; representative members in italics.

ACTIVE MEMBERS.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Adams, A. B		G. F., Gulf, Colo. & Santa Fe	Temple, Tex.
1903	Adams, A. C		M. M., Dela., Lack. & Western	Kingsland, N. J.
1896	Adams, T. E		G. M. M., St. Louis Southwestern	Pine Bluff, Ark.
1888	Addis, J. W.		S. M., P. & R. S., Texas & Pacific	Marshall, Tex.
1895	Aiken, C. L		Boston & Maine	South Lawrence, Mass.
1907	Akans, Geo		M. M., Southern	Birmingham, Ala.
1906	Albright, J. S.		M. M., Mexican Interoceanic	Mexico, Mex.
1887	Aldcorn, Thos		Chicago Pneumatic Tool Co.	95 Liberty st., N. Y. City.
1902	Aldana, H. Lopez		S. M. P., Central Northern	Tucuman, Arg. Rep., S. A.
1906	Allen, C. E.		M. M., Northern Pacific	Livingston, Mont.
1906	Allen, C. W			Reading, Pa.
1892	Allen, G. S		M. M., Philadelphia & Reading	Tamaqua, Pa.
1908	Allison, W. L.		M. E., A. T. & S. F. Ry	Chicago, Ill.
1907	Allport, J. S.		G. F., Copper Range	Houghton, Mich.
1904	Allport, Wm		M. M., Zuni Mountain	Ketner, N. M.
1895	Amann, W. E		Galena Signal Oil Co.	520 Rialto Building, San Francisco, Cal.
1892	Antz, Oscar		G. L. I., New York Central Lines	Dunkirk, N. Y.
1906	Appler, A. B		M. E., Delaware & Hudson Co	Green Island, N. Y.
1887	*Arp, W. C*	211	*S. M. P., Vandalia*	*Terre Haute, Ind.*
1905	Arthur, C. G		M. M., Southern	Columbia, S. C.
1903	Ashton, Harry			401 Delaware ave., Toronto, Ont., Can.
1901	Ashworth, Jas		M. M., Louisville & Nashville	Birmingham, Ala.
1905	Asselin, George		P. E. M. P., Northern Ry. of France	Paris, France.
1896	Atterbury, W. W		G. M., Pennsylvania	Philadelphia, Pa.
1887	Augustus, W		M. M., Chicago, Burlington & Quincy	Centerville, Iowa.
1886	Austin, W. L		Baldwin Locomotive Works	Philadelphia, Pa.
1907	Ayers, A. R.		Asst. Supt. Shops, L. S. & M. S	Collinwood, Ohio.
1903	Ayers, H. B		The Locomotive & Machine Co.	Montreal, Can.
1896	Babcock, C. M.		M. M., Texas & Pacific	McDonoghville, La.
1898	Baker, C. F		Hudson Companies	100 Broadway, N. Y.
1902	Baker, P. G		M. M., Panama	24 State st., New York. Colon (Aspinwall).
1905	Balderston, J. W.			218 South Chicago st., Los Angeles, Cal.
1901	Ball, H. F.		V. P., American Loco. Co.	30 Church st., New York.
1905	Barclay, F. B		M. M., Illinois Central	McComb, Miss.
1906	Bardsley, A.			
1890	Barnum, M. K.		Chicago, Burlington & Quincy	Chicago, Ill.
1906	Barrows, W. H		M. M., K. C. Southern	Shreveport, La.
1895	*Bartlett, Henry*	1060	*S. M. P., Boston & Maine*	*Boston, Mass.*
1904	Barton, T. F		M. M., Illinois Central	Burnside, Chicago, Ill.
1899	Bates, F. L.			2432 Howard st., San Francisco, Cal.
1905	Bather, Fred		M. F., Mexican International	Torreon, Mex.
1889	Bean, S. L		M. S., Santa Fe Lines	Los Angeles, Cal.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1908	Beamer, James A		M.M., Pennsylvania	Tyrone, Pa.
1892	Beattie, A. L.		S. M. P., New Zealand Government.	Wellington, N. Z.
1899	Beauclerk, T. S		Central Argentino	Rosario de Santa Fe, Arg. Rep., S. A.
1894	Beaumont, J. G.		Southern Railways of Peru	Arequipa, Peru.
1892	Bechhold, H. G.		Cleveland Frog & Crossing Co.	Cleveland, Ohio.
1903	Benjamin, F. G.		M. M., Chicago & North-Western	Clinton, Iowa.
1905	Bennett, Geo. R		G. F., Mobile & Ohio	Whistler, Ala.
1903	Bennett, W. J.		A. S. M. P., Chgo., Indpls. & Louisville.	Lafayette, Ind.
1900	Bentley, H. T		A. S. M. P. & M., Chicago & North-West.	Chicago, Ill.
1906	Bentley, L. L.		M. E., Oswego Boiler & Engine Co.	Beaver Falls, Pa.
1902	Berry, Arthur O		S. S., Lake Shore & Michigan Southern.	Elkhart, Ind.
1900	Best, W. N.			11 Broadway, New York.
1903	Billingham, R. A.		G. M. M., Pitts., Shawmut & Northern	St. Marys, Pa.
1902	Bingaman, Chas. A.		Engr. of Tests, Phila. & Reading	Reading, Pa.
1899	Bissett, J. R.		M. M., Seaboard Air Line.	Raleigh, N. C.
1901	Blake, R. P		A. S. S., Northern Pacific.	Brainerd, Minn.
1904	Bock, M. G.		S. M. P. & R. S., De Queen & Eastern.	De Queen, Ark.
1899	Boldridge, R. M		M. M., Central of Georgia.	Cedartown, Ga.
1904	Boler, W. L.			Kingsland, N. J.
1904	Booth, J. S.		M. M., Carolina & Northwestern.	Chester, S. C.
1904	Booth, Thos.		M. S., Pecos Valley Lines.	Amarillo, Tex.
1897	Bowles, C. K		M. M., Tidewater & Western.	Chester, Va.
1907	Boyden, N. N		M. M., Southern	Atlanta, Ga.
1895	Bradeen, J. O		D. S. M. P., N. Y. Cent. & Hudson River	Oswego, N. Y.
1888	Bradley, W. F.		Supt., Ann Arbor	Toledo, Ohio.
1904	Brady, T. F		S. M., Mapini	Mapini, Durango, Mex.
1894	Branch, Geo. E			292 Prospect place, Brooklyn, N. Y.
1896	Brangs, P. H.			11 Broadway, New York City.
1900	Brassell, J. K.		M. M., Cal. Northwestern.	Tiburon, Cal.
1902	Brazier, F. W		S. R. S., N. Y. Cent. & Hudson River.	New York City.
1892	Brehm, W. H.		M. M., Mo., Kan. & Tex.	Parsons, Kan.
1904	Breneman, H. N		A. S. M. P., Chicago, Mil. & St. Paul.	West Milwaukee, Wis.
1879	Briggs, R. H		M. M., St. Louis & San Francisco	Memphis, Tenn.
1898	*Bronner, E. D*	479	*S. M. P., Michigan Central*	*Detroit, Mich.*
1887	Brooke, Geo. D		Panama Canal Commission	Culebra, Canal Zone.
1892	Brown, David		A. S. M. P., Del., Lack. & Western	Scranton, Pa.
1908	Brooks, E. G.		M. M., Mobile & Ohio	Whistler, Ala.
1905	Brown, H. B		M. M., Erie.	Cleveland, Ohio.
1891	Brown, W. A.		M. M., Kanawha & Michigan.	Middleport, Ohio.
1904	Brown, T. A.		S. M. P., Louisiana & Arkansas	Stamps, Ark.
1895	Browne, T. R.		Engr., American Car & Foundry Co.	25 Broad st., New York.
1897	Bruce, Geo. A		G. M. M., Great Northern	St. Paul, Minn.
1890	Bruck, Henry T		M. of M., Cumb. & Penna.	Mt. Savage, Md.
1882	Bryan, H. S.		S. M. P., Duluth & Iron Range.	Two Harbors, Minn.
1906	Bryant, E. G.		D. M. M., International & Great North.	Mart, Tex.
1900	Buchanan, A., Jr.		Public Service Commission	Albany, N. Y.
1902	Buchanan, Jas.			111 South 5th st., Brooklyn, N. Y.
1887	Buchanan, Wm.			26 Fairfield ave., So. Norwalk, Conn.
1906	Burel, W. C.		M. M., Mexican Central	Saltillo, Coah, Mex.
1905	Burgis, E. W		M. M., N. O., Ft. Jackson & Grand Isle.	Algiers, La.
1905	Burkheimer, H. W			Louisville, Ky.
1893	Bush, S. P		G. M., Buckeye Steel Castings Co.	Columbus, Ohio.
1903	Bushmeyer, C. J		M. M., Oklahoma Central.	Purcell, Okla.
1906	Bussing, G. H		S. M. P. & R. S., Evans. & Terre Haute	Evansville, Ind.
1893	*Butcher, Geo. W.*	59	*S. M. P., San Antonio & A. Pass.*	*San Antonio, Tex.*
1904	Cameron, J. E		Mgr., So. Atl. Car & Mfg. Co.	Waycross, Ga.
1903	Campbell, A. A.		M. M., Kansas City Southern	Shreveport, La.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1908	Campbell, S. J.		M. M., C. & A. R. R	Slater, Mo.
1896	Cannon, T. E.		M. M., Great Northern.	Melrose, Minn.
1905	Cardell, J		M. M., Canadian Pacific	Calgary, Alberta, Can.
1902	Caracristi, V. Z			907 Mutual Building, Richmond, Va.
1904	Cargo, B. B		M. M., Lake Terminal.	Lorain, Ohio.
1900	Carney, J. A.		S. S., Chicago, Burlington & Quincy	West Burlington, Iowa.
1907	Carroll, J. T.		A. M. M., Lake Shore & Mich. Southern	Elkhart, Ind.
1903	Carson, F. L.		M. M., El Paso & Southwestern	Alamogordo, N. M.
1907	Carson, H. M.		Asst. to G. M., Pennsylvania.	Philadelphia, Pa.
1889	Casanave, F. D			1710 Market st., Philadelphia, Pa.
1890	Casey, J. J.		Supt., American Car & Foundry Co	Jeffersonville, Ind.
1904	Cassidy, D. E.		M. M., Pennsylvania.	Verona, Pa.
1892	Chamberlin, E.			610 Grand Central Depot, New York City.
1903	Chambers, C. E.		M. M., Central R. R. of N. J	Jersey City, N. J.
1893	Chambers, John S.		S. M. P., Atlantic Coast Line.	Rocky Mount, N. C.
1901	Chase, C. F.		American Locomotive Co	Manchester, N. H.
1904	Chester, W. E			118 Gaston st., W., Savannah, Ga.
1905	Chidley, Joseph.		M. M., Lake Shore & Mich. Southern.	Elkhart, Ind.
1906	Chisholm, J. E.		Ward-Packer Supply Co	Chicago, Ill.
1898	Christopher, J		M. M., Toronto, Hamilton & Buffalo.	Hamilton, Ont., Can.
1908	Chrysler, W. P.		S. M. P., Chgo. Great Western	Oelwein, Iowa.
1902	Churchward, G. J.		Great Western.	Swindon, England.
1905	Clark, David		M. M., Arizona & New Mexico	Clifton, Ariz.
1899	*Clark, F. H*	1346	*G. S. M. P., Chicago, Burl. & Quincy*	*Chicago, Ill.*
1886	Clark, Isaac W			Fayetteville, N. C.
1903	Clark, J. H.		M. M., Staten Island R. T	Clifton, S. I., New York.
1897	Clarke, Owen.		M. M., Texas & Pacific	Marshall, Tex.
1903	Clarkson, W. S		G. M. M., Northern Pacific.	Livingston, Mont.
1901	Clay, S. B.			1220 N. 6th st., Ft. Smith, Ark.
1893	Cleaver, F. C		S. M. P., Rutland	Rutland, Vt.
1877	Clifford, J. G		M. M., Louisville & Nashville	10th and Kentucky sts., Lousiville, Ky.
1887	Cloud, John W			82 York Road, King's Cross, London, Eng.
1903	Cockfield, William		Loco. Supt., Peruvian Southern.	Arequipa, Peru.
1896	Cole, F. J		American Locomotive Co.	30 Church st., N. Y. City.
1904	Cole, T. J.		M. M., Erie.	Meadville, Pa.
1908	Cole, W. H.		M. M., United Verde & Pacific	Jerome, Ariz.
1908	Cook, T. R.		A. E. M. P., Penna. Lines	Ft. Wayne, Ind.
1907	Collier, L. L.		M. M., Louisiana & North-West.	Gibsland, La.
1907	Collins, J. M.		M. M., N. Y. New Haven & Hartford	Harlem River, N. Y.
1906	Collins, W. H.		M. M., Fonda, Johnstown & Gloversville.	Gloversville, N. Y.
1906	Conners, J. J		M. M., Chicago, Milwaukee & St. Paul.	Dubuque, Iowa.
1890	*Conolly, J. J*	93	*S. M. P., Dul., So. Shore & Atlantic.*	*Marquette, Mich.*
1879	Cook, John S		M. M., Georgia.	Augusta, Ga.
1904	Cooper, F. R		S. M. P., Kansas City Southern.	Pittsburg, Kan.
1907	Cooper, G. W.		M. M., Mexican Central	Aquascalientes, Mex.
1902	Cota, A. J.		M. M., Chicago, Burlington & Quincy	Chicago, Ill.
1908	Courtney, E. G		M. M., Ark., La. & Gulf.	Monroe, La.
1904	Coutant, M. R.		M. M., Ulster & Delaware	Rondout, N. Y.
1900	Crawford, D. F		G. S. M. P., Pennsylvania Lines.	Pittsburgh, Pa.
1904	Cromwell, O. C		M. E., Baltimore & Ohio	Baltimore, Md.
1902	Cross, C. W		Supt. Apprentices, N. Y. Cent. Lines.	New York City.
1893	*Cross, W.*	504	*Asst. to 2d V. P., Canadian Pacific.*	*Winnipeg, Man., Can.*
1908	Cullinan, John.		M. M., Central Indiana.	Muncie, Ind.
1899	Cumback, R. O		Vacuum Cleaner Co.	Plainfield, N. J.
1906	Cunningham, D. W.		A. S. M., Mo. Pac. Ry.	Baring Cross, Ark.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1900	Curley, M. S.		S. M. P., Sierra Ry. of Cal	Jamestown, Cal.
1903	Curry, H. M.		G. M. M., Northern Pacific	St. Paul, Minn.
1903	Curtis, Theo. H.		S. M., Louisville & Nashville.	Louisville, Ky.
1904	Cutler, T. J		M. M., Northern Pacific	Missoula, Mont.
1899	Davis, Chas. H		Barclay R. R	So. Yarmouth, Mass.
1906	Davis, David E.		M. M., Boston & Maine	Concord, N. H.
1892	Davis, Ed. E			Newmarket, N. H.
1900	Davisson, F. E		S. M., San Pedro, Los Angeles & Salt Lake	Los Angeles, Cal.
1897	Dawson, E.			Osceola, Iowa.
1903	Dawson, L. L		M. M., Illinois Central	McComb, Miss.
1891	*Deems, J. F*	2881	*G. S. M. P., New York Central Lines.*	*New York City.*
1905	Deeter, D. H		M. M., Philadelphia & Reading.	Reading, Pa.
1896	De Gress, C		Mexican National Construction Co.	Colima, Mex.
1897	Delaney, C. A		American Locomotive Co.	Scranton, Pa.
1895	Delaney, H			14 Stuyvesant place, Staten Island, N. Y.
1905	Delaney, S. J.		M. M., N. Y. C. & H. R. R. R.	West Albany, N. Y.
1899	Delano, F. A		Prest., Wabash	Chicago, Ill.
1900	Demarest, T. W		S. M. P., Pennsylvania Lines.	Ft. Wayne, Ind.
1905	Desmond, D. G		M. M., Morgantown & Kingwood	Morgantown, W. Va.
1903	Deverell, A. C		A. S. M. P., Great Northern	St. Paul, Minn.
1908	De Vilbiss, G. J.		S. M. P., Hocking Valley	Columbus, Ohio.
1907	De Voy, J. F		M. E., Chicago, Milwaukee & St. Paul	W. Milwaukee, Wis.
1905	Dewey, J. J		M. M., Erie.	Jersey City, N. J.
1896	Dickerson, S. K.		A. S. M. P., Lake Shore & Mich. Southern	Cleveland, Ohio.
1887	Dickson, G. L		American Locomotive Co	Scranton, Pa.
1902	Dickson, Geo.			1400 Boston Road, N. Y. City.
1905	Dickson, John		M. M., Great Northern	Devils Lake, N. D.
1907	Diehr, C. P.		M. M., N. Y. Central & Hudson River	Jersey Shore, Pa.
1900	Dillon, S. J.		M. M., Pennsylvania.	Camden, N. J.
1905	Dinan, Arthur.		M. M., Atchison, Topeka & Santa Fe.	Ft. Madison, Iowa.
1905	Dinkel, M. C		S. M. P. & M., Ixt., Mani & Nijini Ry	Ixtlahuaca, Mex.
1894	Dixon, W. F		Singer Co	Podolsk, Moscow, Govt., Russia.
1897	Doebler, C. H			909 W. Berry st., Ft. Wayne, Ind.
1905	Dolan, J. P.		M. M., St. Louis & No. Arkansas	Eureka Springs, Ark.
1898	Dolan, S. M.		M. M., Missouri Pacific.	Sedalia, Mo.
1904	Dooley, W. H		M. M., Cin., New Orleans & Tex. Pac.	Birmingham, Ala.
1903	Doonan, W. F		M. M., Great Northern	Whitefish, Mont.
1907	Dorsey, J. P.			1007 Swan st., Parkersburg, W. Va.
1893	Dow, Jas. M.			Kenton, Ohio.
1899	Downing, T. M		M. M., Virginia & Carolina Coast	Suffolk, Va.
1893	Drury, Michael J.		M. M., Atchison, Topeka & Santa Fe.	La Junta, Colo.
1908	Dresser, K. L.		M. M., Chgo., Cin. & Lo.	Peru, Ind.
1908	Dreyfus, T. F		S. M. P., Buffalo & Susquehanna	Galeton, Pa.
1904	Dunham, W. E.		M. M., Chicago & North-Western	Winona, Minn.
1900	*Dunn, A. J*	20	*M. M., Virginia & Southwestern.*	*Bristol, Va.*
1896	*Dunn, J. F.*	190	*S. M. P., Oregon Short Line.*	*Salt Lake City, Utah.*
1904	Durborow, R. N		S. M. P., Pennsylvania.	Altoona, Pa.
1906	Durham, H. P.		S. M. P., Tehuantepec National	Rincon, Ant., Oaxaca, Mex.
1906	Durrell, D. J		M. M., Pennsylvania Lines	Cincinnati, Ohio.
1906	Edmonds, G. S		M. M., Delaware & Hudson Co	Oneonta, N. Y.
1905	Edmondson, W. G		E. of T., Philadelphia & Reading	Reading, Pa.
1899	Egan, J. A		G. F., Mexican Southern	Oaxaca, Mex.
1900	Elden, Edw		M. M., N. Y. C. & H. R. R. R.	East Buffalo, N. Y.
1906	Elliott, J. B		G. M. M., Canadian Pacific	Montreal, Can.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1908	Elliott, J. B		M. M., Balt. & Ohio	New Castle, Pa.
1899	Ellis, H. D		Anglo-Chilian Nitrate & Railway Co	Tocapilla, Chili.
1893	Ellis, John J		S. M. P. & M., C. St. P. M. & O.	St. Paul, Minn.
1906	Elordi, Manuel		Gen. Insp. Mach., Argentine Govt. Ry	New York City.
1901	Emerson, G. H		S. M. P., Great Northern	St. Paul, Minn.
1906	Emerson, H.			32 Cortlandt st., New York City.
1893	English, H. W.			Birmingham, Ala.
1893	English, Richard			114 Shotwell st., San Francisco, Cal.
1905	Enright, J. F		S. M. P., International & Great Northern.	Palestine, Tex.
1898	Ettinger, R. L.		C. M. E., Southern	Washington, D. C.
1908	Evans, R. C.		S. M. P., Western Maryland	Hagerstown, Md.
1907	Evens, J. W.		M. M., Alabama Great Southern.	Birmingham, Ala.
1900	Ewing, J. J		M. E., Chesapeake & Ohio	Richmond, Va.
1908	Fairbank, J. F.		M. M., Malvern & Freer Valley.	Malvern, Ark.
1900	Feeley, T. M			Marshalltown, Iowa.
1885	Ferguson, G. A		Boston & Albany R. R.	So. Station, Boston, Mass.
1905	Ferguson, L. B		M. M., Vicksburg, Shreveport & Pacific.	Monroe, La.
1904	Ferguson, T. G		Cordova & Rosario	Nuevo Alberdi, Arg. Rep., S. A.
1904	Fetner, W. H.		M. M., Central of Georgia.	Macon, Ga.
1901	Fildes, Thos.		Gold Car-Htg. & Ltg. Co	Richmond Hill, L. I., N. Y.
1907	Finch, Roland.		Beyer, Peacock & Co	Yokohama, Japan.
1907	Fisher, O. A.			4408 Indiana ave., Chicago, Ill.
1905	Fitzgerald, W. T.		M. M., Idaho & Washington Northern.	Spirit Lake, Idaho.
1892	Fitzmorris, Jas		M. M., Chicago Junction	Union Stock Yards, Chicago, Ill.
1908	Fitzsimmons, E. S		M. M., Erie.	Hornell, N. Y.
1906	Flavin, J. T.		M. M., Chgo., Ind. & Southern	Kankakee, Ill.
1903	Fleischer, J. F		M. M., Chicago & North-Western	Sioux City, Iowa.
1903	Flory, B. P.		M. E., Central of New Jersey.	Jersey City, N. J.
1901	*Fogg, J. W.*	39	*M. M., Chicago Terminal Transfer*	*East Chicago, Ind.*
1896	*Foque, T. A*	155	*M. S., M. St. Paul & Sault Ste. Marte.*	*Minneapolis, Minn.*
1905	Ford, Daniel W.		M. M., Pacific Coast	San Luis Obispo, Cal.
1905	Forster, John.		M. M., St. Louis & San Francisco	Kansas City, Mo.
1900	Forsyth, A.		S. S., Chicago, Burlington & Quincy	Aurora, Ill.
1888	Forsyth, Wm.		M. E., *The Railroad Age Gazette*	Chicago, Ill.
1908	Foster, O. M		M. M., L. S. & M. S. Ry	Elkhart, Ind.
1904	Foster, W. T		M. M., Tennessee Copper Co.'s Ry	Copperhill, Tenn.
1877	Fowle, I. W			Riverside, Cal.
1907	Fowler, Henry.		Asst. Wks. Mgr., Midland Ry. of England	Derby, England.
1907	Foyle, Chas. E.		M. M., Susquehanna & New York	Towanda, Pa.
1906	Franey, M. D.		S. S., Lake Shore & Mich. Southern	Collinwood, Ohio.
1907	Fraps, J. C.		M. M., Aberdeen & Ashboro	Biscoe, N. C.
1907	Fraser, Thos		M. M., Algoma Central	Sault Ste. Marie, Ont.
1906	French, G. W		M. M., Little Rock & Hot Spgs. Western.	Hot Springs, Ark.
1891	French, R. E.		Southern Pacific	Oakland, Cal.
1898	Frey, N		M. M., Chicago, Burlington & Quincy	La Crosse, Wis.
1906	Friere, de Silva, J. G		L. S., Central Ry. of Brazil	Rio de Janeiro, Brazil, S. A.
1904	Fries, A. J		M. M., Boston & Albany	Springfield, Mass.
1908	Fritsch, C. M		M. M., Western Maryland	Hagerstown, Md.
1903	Fryburg, F. M.		G. M. M., Great Northern	Minot, N. D.
1890	*Fuller, C. E*	234	*S. M. P., Union Pacific*	*Omaha, Neb.*
1907	Fulmor, J. H		M. M., Pennsylvania.	Pottsville, Pa.
1897	Gaines, F. F.		S. M. P., Central of Georgia.	Savannah, Ga.
1904	Gairns, A. H		M. M., Denver & Rio Grande	Denver, Colo.
1891	Galbraith, R. M			Pittsburg, Kan.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1901	Gallagher, G. A.		M. M., Southern Indiana	Bedford, Ind.
1904	Galloway, W. S.			Baltimore, Md.
1904	Gannon, J. B.		M. M., N. Y., New Haven & Hartford	East Hartford, Conn.
1887	Garstang, Wm.		S. M. P., C. C. C. & St. L	Indianapolis, Ind.
1900	Gaskins, W. B.		G. F., Southern Pacific.	Sparks, Nev.
1903	Gauthier, Jesse		M. M., Copper Range	Houghton, Mich.
1886	Gentry, T. W.		American Locomotive Co.	Richmond, Va.
1905	George, Wm. E		Western Australian Rys.	Perth, Australia.
1899	Gibb, T. M.		G. S., Crystal River	Redstone, Colo.
1888	Gibbs, A. W.		G. S. M. P., Pennsylvania	Altoona, Pa.
1890	Gibbs, George			10 Bridge st., New York.
1902	Gibson, J. A.		M. M., C. C. C. & St. L	Urbana, Ill.
1904	Gilbert, E. B.		S. M. P., Bessemer & Lake Erie	Greenville, Pa.
1905	Gilbert, F. M		M. E., N. Y. C. & H. R. R. R	G. C. Sta., N. Y. City.
1896	Gill, John.		S. M. P., Chicago, Indpls. & Louisville	Lafayette, Ind.
1905	Gillett, L. D.		M. M., Norfolk & Western	Bluefield, W. Va.
1891	Gillis, H. A			Home Life Building, Washington, D.C.
1883	Gilmore, W. L.			Elkhart, Ind.
1893	Gilmour, George		Travelers' Insurance Co.	Hartford, Conn.
1891	Glass, John C.		M. M., Pennsylvania.	Verona, Pa.
1905	Goodale, R. J			1121 Grand ave., St. Louis, Mo.
1904	Goodman, J. E		M. M., Northern Pacific	Duluth, Minn.
1907	Goodrich, G. P		M. M., Ft. Smith & Western	Ft. Smith, Ark.
1905	Goodrich, Max		M. M., New York & Ottawa	Ottawa, Ont., Can.
1880	Gordon, H. D			71 John st., New York.
1906	Gossett, C. E.		S. M. P., Chicago Great Western	Oelwein, Iowa.
1900	Gould, J. E		S. M. P., Norfolk & Southern	Berkley, Va.
1904	Gould, J. R		M. M., Chesapeake & Ohio.	Richmond, Va.
1899	Gould, R		Buenos Ayres Great Southern.	River Plata House, Finsbury Circus, London, England.
1892	Graham, Charles.			401 Madison ave., Scranton, Pa.
1894	Graham, J. A.		G. F., Louisville & Nashville.	Columbia, Tenn.
1903	Graham, S. C.		M. M., Chicago & North-Western	Lake City, Iowa.
1903	Grandy, W. S		D. F., Atchison, Topeka & Santa Fe	Bakersfield, Cal.
1894	Grant, A. S		M. M., Missouri Pacific.	De Soto, Mo.
1906	Gray, B. H.		M. M., New Orleans Terminal.	New Orleans, La.
1906	Gray, G. M.		M. E., Bessemer & Lake Erie	Greenville, Pa.
1906	Greard, Henry Octave		A. S. M. P., French State Rys.	Paris, France.
1889	Greatsinger, J. L.		Brooklyn Rapid Transit.	Brooklyn, N. Y.
1897	Greaven, Luis		S. M. P., Buenos Ayres Gt. Sou	Buenos Ayres, Arg. Rep., S. A.
1905	Green, H		M. E., So. Balto. Steel Car & Fdy. Co	Baltimore, Md.
1895	Green, Wilbur		M. M., San Antonio & Aransas Pass.	Yoakum, Tex.
1905	Greenwood, B. E.		G. F., Seaboard Air Line Ry	Portsmouth, Va.
1885	Griffith, Fred B.			797 Elmwood ave., Buffalo, N. Y.
1907	Griffith, R		M. M., Colorado Midland	Colorado City, Colo.
1908	Grimshaw, F. G		M. M., Penn. R. R.	Camden, N. J.
1908	Gross, E. G		M. M., Central of Georgia.	Columbus, Ga.
1893	Gross, R. J.		American Locomotive Co	New York.
1896	Groves, J. R.			Denver, Colo.
1900	Gurry, Geo.		G. S., American Locomotive Co	Allegheny, Pa.
1906	Guthbrod, F. W		German Consulate	New York.
1893	Hainen, J.		S. M. P., Southern.	Greensboro, N. C.
1898	*Hair, John.*	194	*S. M. P., Baltimore & Ohio S.-W.*	***Cincinnati, Ohio.***
1906	Hale, H. H.		A. M. M., Pere Marquette	Grand Rapids, Mich.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1904	Hall, Chas. S.		M. M., Boston & Maine	Springfield, Mass.
1904	Hall, Grant		A. S. M. P., Canadian Pacific	Winnipeg, Man., Can.
1907	Hamilton, W. H.		M. M., Atchison, Topeka & Santa Fe.	Argentine, Kan.
1908	Hamilton, Taber.		M. M., Cumb. Valley.	Chambersburg, Pa.
1902	*Hammett, P. M*	167	*S. M. P., Maine Central.*	*Portland, Me.*
1905	Hammond, G. O		M. E., Erie	Meadville, Pa.
1891	Hancock, Geo. A.		S. M. P., St. Louis & San Francisco.	Springfield, Mo.
1893	Hancock, Wm. S.		Waters-Pierce Oil Co	St. Louis, Mo.
1908	Hanlin, J. J.		M. M., Seaboard Air Line.	Atlanta, Ga.
1907	Hardie, R. J.		Union Foundry & Machine Works	Valparaiso, Chili.
1905	Harkon, J. W		G. S., Canada Foundry Co.	Toronto, Can.
1906	Harrigan, P. J.		M. M., Baltimore & Ohio	Connellsville, Pa.
1906	Harrington, H. H		M. M., Erie.	Susquehanna, Pa.
1907	Harris, C. M.		M. M., Washington Terminal.	Washington, D. C.
1902	Harris, J. D		Westinghouse Air Brake Co.	Wilmerding, Pa.
1898	Harrison, F. J		M. M., Buffalo, Rochester & Pittsburg.	Du Bois, Pa.
1896	Harrison, John		San Paulo.	San Paulo, Brazil, S. A.
1904	Harrison, W. L.		S. M. P., Chicago, Rock Island & Pacific.	Cedar Rapids, Iowa.
1903	Hartigan, B.		G. F., Rutland.	Rutland, Vt.
1901	Haselton, G. H			West Albany, N. Y.
1889	Haskell, B			Franklin, Pa.
1888	Hassman, Wm.		M. M., Peoria & Pekin Union.	Peoria, Ill.
1908	Hatah, S. K.		C. S. M. P., Imperial Govt. Ry.	Tokyo, Japan.
1905	Hatz, G. K.		S. S., Union Pacific.	Omaha, Neb.
1900	Hawkins, B. H		M.M., Del., Lack. & Western.	Buffalo, N. Y.
1903	Hawkins, R. D		M. E., Great Northern	St. Paul, Minn.
1899	Hawthorne, J			Susquehanna, Pa
1908	Hayes, C. W		M. M., Blue Ridge Ry	Anderson, S. C.
1906	Hayes, J. T		M. M., Grand Rapids & Indiana	Grand Rapids, Mich.
1903	Hayes, W. C		Supt. Loco. Operation, Erie.	New York City.
1905	Haynen, W. J			
1896	Hayward, H. S		S. M. P., Pennsylvania.	Jersey City, N. J.
1891	Hedley, F.		G. M., Interborough R. T. Ry. Co	New York City.
1887	Heintzleman, T. W.		S. M. P., Southern Pacific	Sacramento, Cal.
1892	Henderson, G. R.			20 W. 34th st., New York.
1907	Henry, Wm		A. M. M., St. Louis & San Francisco	Memphis, Tenn.
1908	Henry, W. C. A.		S. M. P., Penna. Lines West	Columbus, Ohio.
1907	Herr, E. E.		M. M., Pennsylvania.	Camden, N. J.
1892	Herr, Edwin M		V. P., Westinghouse Air Brake Co.	Wilmerding, Pa.
1903	Herr, H. T			Duquesne, Ariz.
1908	Hess, Geo. F		M. M., Balt. & Ohio	Lorain, Ohio.
1895	Hibbard, H. Wade.		Cornell University.	Ithaca, N. Y.
1903	Hickey, F. P		American Locomotive Co	Richmond, Va.
1901	Hickey, P. J.		M. M., C. C. C. & St. L	Mattoon, Ill.
1906	Hicks, I. C		M. M., Santa Fe Lines.	San Bernardino, Cal.
1890	Higgins, S		G. M., N. Y., New Haven & Hartford	New Haven, Conn.
1901	Hildreth, F. F		M. E., Vandalia.	Terre Haute, Ind.
1901	Hilferty, C. D		Cooke Locomotive Works	Paterson, N. J.
1887	Hill, Jas. W			Peoria, Ill.
1906	Hill, John.		M. M., Lake Erie & Western.	Tipton, Ind.
1896	Hill, Rufus.		M. M., Pennsylvania.	Pavonia, N. J.
1904	Hill, W. H		M. M., Cornwall.	Lebanon, Pa.
1908	Hill, W. J.		G. F., A. T. & S. F. Ry.	La Junta, Colo.
1902	Hillman, C. R		A. S. M. P., San Paulo	San Paulo, Brazil, S. A.
1906	Hinckley, A. C.		M. M., Cincinnati, Hamliton & Dayton.	Lima, Ohio.
1906	Hobbs, H. L		M. M., South & Western.	Johnson City, Tenn.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1902	Hobson, W. P.		A. M. M., Chesapeake & Ohio	Lexington, Ky.
1907	Hocking, Jas.		M. M., N. Y., New Haven & Hartford	South Boston, Mass.
1907	Hodges, A. H.		M. M., Baltimore & Ohio	Cumberland, Md.
1906	Hoffman, C. M.		M. M., Southern	Princeton, Ind.
1899	Hoffman, R. F.			10 Bloom st., Danville, Pa.
1908	Hoffmeister, F. S		A. M. M., N. Y. P. & N. R. R	Cape Charles, Va.
1901	Hogan, C. H		D. S. M. P., N. Y. C. & H. R. R. R.	Depew, N. Y.
1892	Holland, W. D.		M. M., Philippine Ry	Iloilo, P. I.
1890	Homer, John C		A. M. M., Cin., Hamilton & Dayton.	Indianapolis, Ind.
1896	Hopwood, John.		Argentine Great Western	51 Ennerdale Rd., Richmond, Surrey, Eng.
1896	*Horrigan, John*	138	*S. M. P., E. J. & E., C. L. S. & E. Rys*	*Joliet, Ill.*
1906	Horsey, A. W		M. E., Canadian Pacific	Montreal, Can.
1892	Howard, C. H			504 Columbia Bldg., St. Louis, Mo.
1896	Howard, John		S. M. P., New York Central Lines	New York City.
1905	Howe, H. B		New South Wales Rys	Sydney, Australia.
1899	Hudson, H. G			1436 84th st., Cleveland, Ohio.
1904	Hudson, W. H.			Birmingham, Ala.
1903	Hufman, W. H		M. M., Chicago & North-Western.	Baraboo, Wis.
1890	Hufsmith, F.			Palestine, Tex.
1905	Hume, E. S		C. M. E., Western Australian Govt. Rys	Midland Jct., Australia.
1890	Humphrey, A. L.		G. M., Westinghouse Air Brake Co.	Pittsburgh, Pa.
1906	Hungerford, S. J.		S. L., Works, Canadian Pacific	Winnipeg, Man.
1904	Hunt, H. B		American Locomotive Co.	Chicago, Ill.
1906	Hunter, G. S		D. M. M., Kansas City Southern	Pittsburg, Kan.
1905	Hunter, H. S		M. M., Philadelphia & Reading.	Philadelphia, Pa.
1896	Hyndman, F. T.			1472 Chapel st., New Haven, Conn.
1900	Irwin, J. E.		M. M., Marietta, Columbus & Cleveland	Marietta, Ohio.
1908	Iwasaki, H.		T. M., Imperial Govt. Rys.	Tokyo, Japan.
1907	Jackson, Harry		C. E., Texas & Mex. Ltg. & Power Co.	Eagle Pass, Tex.
1908	Jacobs, H. W.		A. S. M. P., A. T. & S. F. Ry.	Topeka, Kan.
1907	James, Charles		M. M., Erie.	Galion, Ohio.
1899	James, E. T		M. M., N. Y., New Haven & Hartford	New Haven, Conn.
1896	James, Geo.		M. M., N. Y. C. & St. L	Station S, Chicago, Ill.
1907	Jaynes, R. T		M. M., Lehigh & Hudson River.	Warwick, N. Y.
1900	Jennings, Thos		M. M., Boston & Maine	Keene, N. H.
1890	Jennings, Wm		Pacific Electric Ry	Los Angeles, Cal.
1896	Johnson, A. B		Baldwin Locomotive Works	Philadelphia, Pa.
1902	Johnson, Ben.			
1887	Johnson, L. R		S. M. P., Canadian Pacific	Montreal, Can.
1903	Johnson, R. A			Gùaymas, Sonora, Mex.
1898	Johnson, R. H.			Ortega, Mex., D. F.
1908	Johnson, Rankin.		G. M., Bolivia Ry. Co.	La Paz, Bolivia, S. A.
1903	Johnson, W. O.		M. M., Empire Shops	Canal Zone.
1905	Jones, C. F		M. M., Natchez, Urania & Ruston	Urania, La.
1888	Joughins, G. R		M. S., Intercolonial.	Moncton, N. B., Can.
1903	Jungling, M			
1896	Justice, D. J.			722 W. Chestnut st., Louisville, Ky.
1905	Kaderly, W. F.		M. M., Southern	Spencer, N. C.
1890	Kalbaugh, I. N		Coal & Coke Ry.	Gassaway, W. Va.
1903	*Kapp, W. F.*	51	*S. S. & M., Rich., Fred. & Potomac*	*Richmond, Va.*
1907	Kastlin, Jacob.		Supt., Davenport Loco. Works.	Davenport, Iowa.
1904	Kearney, Alex.		A. S. M. P., Norfolk & Western	Roanoke, Va.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1892	*Keegan, Jas. E*	92	*S. M. P., Grand Rapids & Indiana*	*Grand Rapids, Mich.*
1908	Kehoe, R. H		M. M., Nor. & Sou. Ry	New Bern, N. C.
1904	Kellogg, W. L.		M. M., Pere Marquette	Detroit, Mich.
1896	Kells, Willard		M. M., Lehigh Valley	Buffalo, N. Y.
1896	Kelly, Wm.		G. M. M., Great Northern	Spokane, Wash.
1905	Kendall, H. H.		S. M. P., St. L., Brownsville & Mexico	Kingsville, Tex.
1904	Kendig, R. B.		M. E., Lake Shore & Mich. Southern	Cleveland, Ohio.
1894	Kennedy, Jas			158 Prospect st., Cambridge, Mass.
1901	Keyworth, T. E.		Cuban Central Rys., Ltd	Sagua La Grande, Cuba.
1908	Kiler, J. R		M. M., C. Y. R. & P. Ry.	Guaymas, Sonora, Mex.
1903	Kilpatrick, J. B.		A. S. M. P., Chicago, R. I. & Pacific.	Chicago, Ill.
1900	Kilpatrick, R. F			Scranton, Pa.
1903	Kinnaird, L. S.		M. M., Cleveland, Akron & Columbus	Mt. Vernon, Ohio.
1905	Kinney, W. H		M. M., New York, Ontario & Western	Carbondale, Pa.
1904	Kirkpatrick, Jas		M. M., Baltimore & Ohio	Newark, Ohio.
1902	Knight, Wm. Enw		G. M. M., United Rys. of Havana.	Havana, Cuba.
1908	Knight, G. E		G. M. M., Cuba R. R.	Camaguay, Cuba.
1902	Krauss, J. I		M. M., K. C. Southern	Mena, Ark.
1907	Kurman, A. G.		M. M., Mt. Jewett, Kinzua & Riterville.	Kushequa, Pa.
1905	Kyle, C.		M. M., Canadian Pacific	Montreal, Que.
1899	Lachlan, Wm		Manaos Improvements, Ltd	Manaos, Amazqmas, Brazil.
1898	Lake, E. M.		Camp & Hinton Co.	Lumberton, Miss.
1888	Lape, C. F			216 Stimson Block, Los Angeles, Cal.
1907	Larrey, T.		M. M., Interoceanic R. R.	Jalapa, Vera Cruz, Mex.
1907	Larry, W. L.		M. M., N. Y., New Haven & Hartford	Taunton, Mass.
1907	Latta, H. P		M. M., Seaboard Air Line.	Jacksonville, Fla.
1905	Laurent, Theo.		A. C. E., Paris & Orleans Ry.	Paris, France.
1891	Lawes, T. A.		M. E., New York, Chicago & St. Louis	Cleveland, Ohio.
1890	Leach, H. L.			75 Wallingford Road, Brighton, Mass.
1903	Leach, W. B			383 Dorchester ave., South Boston, Mass.
1892	Lee, C. W.			Greensboro, N. C.
1904	Leeman, W. W			1031 N. Wahsatch ave., Colorado Springs, Colo.
1888	Leigh, F. J.			30 Kenilworth Road, Ealing, London, W., Eng.
1890	Leonard, A. G.		Chgo. Junction Ry	Chicago, Ill.
1876	*Lewis, W. H*	697	*S. M. P., Norfolk & Western*	*Roanoke, Va.*
1907	Lillie, G. W		S. C. D., St. Louis & San Francisco	St. Louis, Mo.
1906	Lindsley, W. H		M. M., Florida Ry.	Alton, Fla.
1896	Lindstrom, Chas		M. M., Illinois Central	Vicksburg, Miss.
1904	Link, T. C		Union Iron & Brass Works	El Paso, Tex.
1907	Little, J. C		M. E., Chicago & North-Western	Chicago, Ill.
1903	Litton, Francis H		Shansi Honan Ry	Chiaotso, Honan, China.
1890	*Lloyd, T. S.*	1287	*S. M. P., Dela., Lack. & Western*	*Scranton, Pa.*
1905	Lockwood, B. D		M. E., Clev., Cin., Chicago & St. Louis	Indianapolis, Ind.
1895	Lonergan, P. T			W. Springfield, Mass.
1907	Lord, A. W		S. M. P., Quincy & Torch Lake.	Hancock, Mich.
1899	Lovell, Alfred			819 Harrison Bldg., Philadelphia, Pa.
1908	Luscombe, J. T.		M. M., T. & O. C. Ry	Bucyrus, Ohio.
1903	Lyddon, H. A		G. L. F., Northern Pacific	N. Brainerd, Minn.
1894	Lyon, Tracy		Westinghouse Electric & Mfg. Co	Pittsburgh, Pa.
1903	MacBain, D. R		A. S. M. P., N. Y. C. & H. R. R. R.	West Albany, N. Y.
1907	Macbeth, H. A.		M. M., N. Y., Chicago & St. Louis	Conneaut, Ohio.
1890	Macfarlane, T. W		Mobile, Jackson & Kansas City.	Richmond, Kan.
1899	Machesney, A. G.		Baldwin Locomotive Works	Philadelphia, Pa.
1876	Mackenzie, John			60 Hawthorne ave., Cleveland, Ohio.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Magarvey, J. R		American Locomotive Co.	Dunkirk, N. Y.
1896	Maher, P		S. M. P., Chicago & Alton, Toledo, St. Louis & Western	Bloomington, Ill.
1896	Mahl, F. W		G. M. E., Colo. & Southern	Denver, Colo.
1905	Mailer, John			Ft. Smith, Ark.
1899	Malone, I. M			Chihuahua, Mex.
1895	Mallinson, E. P			49 Ashford st., Brooklyn, N. Y.
1904	Malthaner, W		M. M., Delaware & Hudson	Green Island, N. Y.
1894	Manchester, A. E		S. M. P., C. M. & St. P.	West Milwaukee, Wis.
1902	Manchester, H. C		A. S. M. P., Maine Central.	Portland, Me.
1893	*Manning, J. H*	336	*S. M., Delaware & Hudson*	*Albany, N. Y.*
1905	Mannion, T. D.		M. M., Philadelphia & Reading.	Camden, N. J.
1898	Marchbanks, James		Wellington & Manawater.	Wellington, N. Z.
1903	Markle, T. M.			Reno, Nev.
1908	Marea, M		M. M., T. St. L. & W. R. R	Frankfort, Ind.
1890	Marshall, E. S			St. Louis, Mo.
1906	Marshall, Thos		M. M., C. St. P. M. & O. Ry.	St. Paul, Minn.
1891	Marshall, W. H.		Prest., American Locomotive Co	New York City.
1908	Martin, E. L		M. M., Nacozari Ry	Nacozari, Sonora, Mex.
1908	Martin, J. P.		M. M., Liberty White R. R.	McComb, Miss.
1903	May, H. C		M. M., L. & N	New Decatur, Ala.
1907	May, Walter		M. M., Cleve., Cin., Chicago & St. Louis	Louisville, Ky.
1904	Maysilles, J. H.			108 Elmer ave., Schenectady, N. Y.
1906	McArthur, F. A.		M. M., St. Louis & San Francisco	Springfield, Mo.
1907	McCammon, W. I		Supt. L. & C., Mexican So. R. R.	Pueblo, Mex.
1905	McCarthy, M. J.		S. S., C. C. C. & St. L. Ry	Indianapolis, Ind.
1908	McCarthy, T. W		M. M., C. R. I. & P. Ry	Argenta, Ark.
1891	McConnell, J. H			1503 Arrott Bldg., Pittsburg, Pa.
1896	McCormick, A		F. M. Hicks & Co	Chicago Heights, Ill.
1892	*McCuen, J. P*	230	*S. M. P., C. N. O. & T. P. and A.G.S.Rys.*	*Ludlow, Ky.*
1903	McCuen, R. E		M. M., Lexington & Eastern	Lexington, Ky.
1891	McDonough, James			3616 Avenue K, Galveston, Tex.
1905	McDougall, R. M		M. M., Morenci Southern	Morenci, Ariz.
1893	McElvaney, C. T.		M. M., Missouri, Kansas & Texas.	Denison, Tex.
1908	McGee, W. J		M. M., Tampa Nor. R. R	Tampa, Fla.
1908	McGill, A. M		M. M., L. V. R. R	Wilkesbarre, Pa.
1905	McGoff, J. H		M. S., Atchison, Topeka & Santa Fe	Topeka, Kan.
1903	McGrath, J. T.		M. M., Grand Trunk	Ft. Gratiot, Mich.
1905	McHaffie, A. B		M. M., Intercolonial	Moncton, N. B., Can.
1903	McHattie, T.		M. M., Grand Trunk	Montreal, Can.
1890	McIntosh, Wm		S. M. P., Central R. R. of N. J	Jersey City, N. J.
1893	*McKee, G. S.*	219	*S. M. P., Mobile & Ohio*	*Mobile, Ala.*
1901	McKeen, W. R., Jr		C. E. Motor Car Dept., Union Pacific	Omaha, Neb.
1896	McLean, W. J		M. M., Bell., Bay. & Brit. Col	Bellingham, Wash.
1906	McManamy, J		R. F. of E., Pere Marquette	Grand Rapids, Mich.
1894	McMasters, Chas. J.		G. F., Rutland.	Malone, N. Y.
1896	McNabb, T.		M. M., A. R. & C. Co.	Lethbridge, Alb., Can.
1890	McNaughton, Jas		American Locomotive Co	Schenectady, N. Y.
1905	McNulty, F. M		M. M., Monongahela Connecting.	Pittsburgh, Pa.
1905	McRae, J. A.		M. E., Michigan Central.	Detroit, Mich.
1907	Mechling, J. E.		M. M., Vandalia R. R.	Terre Haute, Ind.
1905	Meister, C. L.		M. E., Atlantic Coast Line.	Wilmington, N. C.
1895	Mellin, C. J		American Locomotive Co.	Schenectady, N. Y.
1900	Mendenhall, C. M			2 Rector st., New York City.
1903	*Menzel, W. G.*	190	*S. M. P., Wisconsin Central*	*Fond du Lac, Wis.*
1907	Meredith, H. P		A. E. M. P., Penna. R. R.	Altoona, Pa.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1892	Mertsheimer, F		G. S. M. P., K. C. M. & O. R. R	Kansas City, Mo.
1887	Michael, J. B		M. M., Southern	Knoxville, Tenn.
1885	Millen, Thos.		M. M., Metropolitan Street Ry	106 W. 51st st., N. Y.
1889	*Miller, E. A.*	180	*S. M. P., N. Y. C. & St. L.*	*Cleveland, Ohio.*
1890	Miller, Geo. A		M. M., Florida East Coast	St. Augustine, Fla.
1903	Miller, J. B.		G. F., St. L. Southwestern of Texas.	Waco, Tex.
1901	Miller, S. W		American Locomotive Co	Providence, R. I.
1906	Miller, Wm.		Supt., M. P. & C. D., Western Maryland.	Union Bridge, Md.
1903	Miller, W. J		M. M., St. L. Southwestern of Texas	Tyler, Tex.
1903	Milliken, James.		S. M. P., Phila., Balt. & Washington	Wilmington, Del.
1893	Minshull, P. H.		M. M., N. Y. O. & W.	Middletown, N. Y.
1892	Minto, H. M.		M. M., Louisville & Nashville	Mobile, Ala.
1888	Minton, A. B		M. M., Mobile & Ohio	Jackson, Tenn.
1892	Mitchell, A. E			50 Church st., New York City.
1908	Moan, E. G.		T. E., N. Y. Leather Belting Co	87 Maple st., Jersey City, N. J.
1903	Moir, William		M. S., Northern Pacific	St. Paul, Minn.
1898	Moler, A. L		M. M., Frisco Lines.	Beaumont, Tex.
1907	Moll, George		M. M., Philadelphia & Reading.	Reading, Pa.
1908	Monfee, A. J		M. M., Birmingham Southern R. R	Pratt City, Ala.
1908	Moser, E. L		C. D., P. & R. R. R.	Reading, Pa.
1901	Monahan, J. J		M. M., Louisville & Nashville	Paris, Tenn.
1890	Monkhouse, H.		Rome Loco. & Mach. Works	Rome, N. Y.
1903	Monlaverde, F.		Paulista	Santos, Brazil.
1903	Monroe, M. S.		M. M., Chicago, Lake Shore & Eastern	Chicago, Ill.
1907	Montgomery, Hugh		G. F., Central R. R. of N. J.	Jersey City, N. J.
1884	Montgomery, Wm.		M. M., Central of N. J.	Lakehurst, N. J.
1896	Moran, Robert		M. M., Louisville & Nashville	Nashville, Tenn.
1907	Moran, W. F		M. M., Southern	Sheffield, Ala.
1907	Moriarty, G. A			Port Jervis, N. Y.
1887	Morris, W. S			813 W. Berry st., Ft. Wayne, Ind.
1905	Morrison, J. R.		M. M., Inverness Ry. & Coal Co	Inverness, C. B., Can.
1906	Mowery, J. N.		M. E., Lehigh Valley	So. Bethlehem, Pa.
1901	Muchnic, C. M.		American Locomotive Co.	New York, N. Y.
1904	Mudd, G. W.		M. M., Denver & Rio Grande	Alamosa, Colo.
1899	*Muhlfeld, J. E.*	1843	*G. S. M. P., Baltimore & Ohio.*	*Baltimore, Md.*
1905	Mullen, D. J.		M. M., C. C. C. & St. L	Mt. Carmel, Ill.
1908	Mullinix, J. W.		S. M. P., C. R. I. & P. Ry	Horton, Kan.
1904	Murphy, J. H.		M. M., Cin., New Orleans & Tex. Pac.	Ludlow, Ky.
1890	Murphy, P. H		Murphy Car Roof Co	East St. Louis, Ill.
1905	Murray, W. H		G. F., Atchison, Topeka & Santa Fe	Winslow, Ariz.
1903	Murrian, W. S		S. M. P., Southern.	Knoxville, Tenn.
1904	Needham, E. F.		S. L. & C. D., Wabash	Springfield, Ill.
1908	Neel, T. M., Jr.		M. E., A. B. & A. R. R.	Fitzgerald, Ga.
1905	Nelson, E. D		E. of T., Pennsylvania	Altoona, Pa.
1894	Nettleton, W. A		G. S. M. P., C. R. I. & P. Ry.	Chicago, Ill.
1898	Neubert, G. T		M. M., Chicago Great Western	Oelwein, Iowa.
1892	Neuffer, John G.		S. M., Illinois Central	Chicago, Ill.
1901	Neville, John,		M. M., M. L. & D. Co	Comey, Michoacan, Mex.
1908	New, W. E.		M. M., K. C. Belt Ry	Kansas City, Mo.
1896	Neward, F. H		M. M., Pontiac, Ox. & Northern	Pontiac, Mich.
1906	Newhouse, J. F		M. M., Ken. & Ind. Bridge & R. R.	Louisville, Ky.
1875	Noble, L. C			Fisher Bldg., Chicago, Ill.
1908	Nicholson, Jno.		S. M. P. & M., St. L. B. & M. Ry	Kingsville, Tex.
1902	Nolan, J. C.		M. M., Arkansas Southern.	Ruston, La.
1899	Nolan, J. P.		D. M. M., Morgan's L.& T.R.R.& S. S. Co	Algiers, La.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1906	Noyes, C. T		S. S., Southern Pacific	Sacramento, Cal.
1902	Nutt, Geo. B		L. S., Egyptian State Ry.	Cairo, Egypt.
1896	Nuttall, W. H		M. M., Manistee & Northeastern.	Manistee, Mich.
1905	O'Beirne, P		S. M., Toluca, Marquette & Northern	Toluca, Ill.
1903	O'Hearne, J. E		M. M., Wheeling & Lake Erie	Norwalk, Ohio.
1890	O'Herin, Wm		S. M., Mo., Kan. & Tex	Parsons, Kan.
1895	O'Leary, D		M. M., Columbia & Puget Sound	Seattle, Wash.
1905	Oplinger, J. W.		S. M. P., Atlantic Coast Line.	Savannah, Ga.
1901	Ord, C. R		M. M., Canadian Pacific	McAdam Jct., N. B., Can.
1908	Osborne, C. H		M. M., C. & N.-W. Ry	Baraboo, Wis.
1908	Osborne, H. J		M. M., C. R. I. & P. Ry	Goodland, Kan.
1908	Osborne, R. E		M. M., W. G. & St. L. Ry.	Greenville, Mo.
1907	Oviatt, H. C		M. M., N. Y., New Haven & Hartford	New Haven, Conn.
1906	Owens, W. H.		M. M., Southern	Manchester, Va.
1901	Parish, Le Grand		S. M. P., Lake Shore & Mich. Southern	Cleveland, Ohio.
1900	Parker, M. B			P. O. Box 1, Chattanooga, Tenn.
1905	Parks, Geo. E		M. M., Michigan Central.	Jackson, Mich.
1901	Park, S. T		S. M. P., Chicago & Eastern Illinois.	Danville, Ill.
1903	Park, P. D		M. M., Reid Newfoundland Co.'s	Whitbourne, N. F.
1903	Passmore, H. E.		M. M., Toledo & Ohio Central	Kenton, Ohio.
1879	Patterson, J. S		Galena Signal Oil Co.	Cincinnati, Ohio.
1903	Paul, W. M		M. M., Gal., Houston & Henderson	Galveston, Tex.
1891	Paxton, Thos.		S. M. P., El Paso & South Western	El Paso, Tex.
1904	Pearce, J. S		M. M., Norfolk & Western	Portsmouth, Ohio.
1903	Pearsall, D. M		M. M., Atlantic Coast Line	Florence, S. C.
1899	Pearse, H.		Buenos Ayres & Rosario, La Quinta,	Rosario de Santa Fe, Arg. Rep., S. A.
1887	*Peck, Peter H.*	*75*	*M. M., C. & W. I. and Belt*	*Chicago, Ill.*
1901	Pengelly, J. H			City of Mexico, Mex.
1899	Pennington, J. H			1047 Broadway, New York.
1908	Petries, L. A		M. M., Oaho Ry. & Land Co	Honolulu, Hawaii.
1897	Peyton, H. T.		M. M., Atchison, Topeka & Santa Fe.	La Junta, Colo.
1907	Pfafflin, Louis		M. M., Indianapolis, Union	Indianapolis, Ind.
1907	Pfahler, F. P		M. E., Wheeling & Lake Erie	Norwalk, Ohio.
1897	Pflager, H. M.		Commonwealth Steel Co	St. Louis, Mo.
1900	Phillips, C		M. M., New Orleans & Northeastern	Meridian, Miss.
1906	Phipps, S		M. M., Canadian Pacific	Revelstroke, B. C.
1903	Piccioli, J.		M. M., Colorado & Wyoming.	Minnequa, Colo.
1905	Pierce, F. M.		M. M., Turner & Co	Worth, Ga.
1902	Pilcher, J. A		M. E., Norfolk & Western	Roanoke, Va.
1904	Pinheiro, Antonio.		Mogyana R. R.	Campinos, Brazil, S. A.
1901	Place, F. E.		Buda Foundry & Machine Co	Harvey, Ill.
1900	Plank, P. D		M. M., Louisville, Hend. & St. Louis	Cloverport, Ky.
1903	Platt, J. G			Meadville, Pa.
1897	Pollitt, Harry		Great Central.	Fernlea, Altricham, Cheshire, Eng.
1906	Poole, A. J.		G. M. M., Seaboard Air Line.	Portsmouth, Va.
1900	Post, W. F.		Watkins Foundry & Machine Co.	Hattiesburg, Miss.
1897	Potton, J		M. M., Texas & Pacific.	Big Springs, Tex.
1905	Powell, V. U		M. M., Illinois Central.	Mattoon, Ill.
1906	Powers, M. J		M. M, Delaware & Hudson	Carbondale, Pa.
1903	Pratt, E. W		M. M., Chicago & North-Western	Missouri Valley, Iowa.
1907	Prendergast, A. P.		M. M., Baltimore & Ohio.	Baltimore, Md.
1907	Prendergast, J. L		M. M., Baltimore & Ohio.	Glenwood, Pa.
1903	Prendergast, W. H		R. F. E. M, Central of Georgia.	Savannah, Ga

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1891	Prescott, C. H		M. M., Spokane International	Spokane, Wash.
1905	Preston, Robert		M. M., Canadian Pacific	Toronto Jct., Toronto, Can.
1900	Prince, S. F., Jr.			122 W. 49th st., New York City, N. Y.
1905	Purdy, Jos. B		M. M., Hilo	Hilo, Hawaii.
1890	Purves, T. B., Jr.		S. M. P., Denver & Rio Grande	Denver, Colo.
1888	*Quayle, Robert*	1307	*S. M. P. & M., Chicago & N.-W*	*Chicago, Ill.*
1895	Quereau, C. H		S. E. E., N. Y. C. & H. R. R. R	New York, N. Y.
1908	Quigley, Jos.		M. M., C. N. O. & T. P. Ry	Chattanooga, Tenn.
1908	Randolph, J. L		M. M., B. & M. R. R.	E. Cambridge, Mass.
1890	Randolph, L. S		Virginia Polytechnic Institute	Blacksburg, Va.
1903	Records, J. W		M. M., St. L., Rocky Mtn. & Pacific	Cimarron, N. M.
1901	Redding, D. J		M. M., Pittsburgh & Lake Erie	McKee's Rocks, Pa.
1904	Reeves, P. H		M. M., Baltimore & Ohio	Chillicothe, Ohio.
1902	Reid, W. L.		American Locomotive Co	Schenectady, N. Y.
1883	Renshaw, W			Chicago, Ill.
1892	Rettew, C. E		D. & H. Co.	Carbondale, Pa.
1896	Reynolds, O. H.		Bethlehem Steel Co.	New York City.
1899	Rhodes, L. B.		M. M., Georgia Southern & Florida	Macon, Ga.
1905	Rice, J. H.		M. M., De Queen & Eastern	De Queen, Ark.
1907	Richardson, L. A		M. M., Chicago, Rock Island & Pacific	Trenton, Mo.
1901	Richmond, W. H		M. M., Lake Superior & Ishpeming	Marquette, Mich.
1907	Rieckman, W. H.		A. M. M., Boston & Maine	Mechanicsville, N. Y.
1894	Riley, George N		M. M., McKeesport Connecting	Pittsburgh, Pa.
1902	Robb, J. M.		M. M., Chicago Great Western	Chicago, Ill.
1901	Robb, W. D.		S. M. P., Grand Trunk	Montreal, P. Q.
1901	Roberts, Jos		M. M., Union Pacific	Kansas City, Kan.
1896	Roberts, J. W			1237 Bellefontaine st., Indianapolis, Ind.
1895	Robinson, Frank		Robinson Co	Boston, Mass.
1903	Robinson, Maynard		M. M., Gulf, Colo. & Santa Fe	Temple, Tex.
1906	Roesch, F. P		M. M., Southern	Spencer, N. C.
1896	Rogers, M. J			1008 West 24th st., Kansas City, Mo.
1903	Rogers, R. H.			21 Lee place, Paterson, N. J.
1900	Roope, Thos		S. M. P., Chicago, Burl. & Quincy	Lincoln, Neb.
1896	Rosing, W. H. V.		M. E., Missouri Pacific	St. Louis, Mo.
1895	Royal, C. B			101 Holly court, Oak Park, Ill.
1898	Rumney, T		G. M. S., Erie	New York, N. Y.
1896	Rusch, Peter C		M. M., Buffalo, Rochester & Pittsburgh	Bradford, Pa.
1907	Russell, A. C		M. M., Inter-California	Clifton, Cal.
1907	Russell, W. B		Asst. Supt. Apprentices, N. Y. C. Lines	New York City.
1903	Russell, W. H		M. M., Southern Pacific	W. Oakland, Cal.
1893	Ryan, E		M. M., Gal., Houston & San Antonio	San Antonio, Tex.
1891	Ryan, J. J		S. M. P., Southern Pacific	Houston, Tex.
1892	Ryan, Patrick		M. M., Louisville & Nashville	Russellville, Ky.
1892	Sague, J. E		Public Service Commission, 2d District	Albany, N. Y.
1906	Sakuma, T.		M. E., Imp. Govt. Ry	Shimbashi, Tokyo, Japan.
1887	Sample, N. W		Baldwin Locomotive Works	Philadelphia, Pa.
1896	Sanderson, R. P. C.		S. M. P., Virginian Ry	Norfolk, Va
1908	Sasser, E. C.		M. M., Southern Ry	Charlestown, S. C.
1903	*Scheffer, F. H*	234	*S. M. P., Nashville, Chatt. & St. Louis*	*Nashville, Tenn.*
1903	Schilling, R. P.		M. M., Del., Lack. & Western	Utica, N. Y.
1905	Schlacks, W. J.			Old Colony Bldg., Chicago, Ill.
1904	Schlafge, Wm		M. S., Erie	Jersey City, N. J.
1901	Seabrook, C. H		M. M., St. Louis Southwestern	Teague, Tex.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1907	Sechrist, T. O		M. M., Cin., N. O. & Texas Pacific	Somerset, Ky.
1907	Seddon, C. W		S. M. P., Duluth, Missabe & Northern.	Proctor (St. Louis Co.), Minn.
1875	Sedgwick, E. V			Galena Signal-Oil Co., Franklin, Pa.
1900	Seidell, G. W.		Supt. Shops, Chicago, R. I. & Pacific	Silvis, Ill.
1900	Seley, C. A.		M. E., Chicago, Rock Island & Pacific.	Chicago, Ill.
1907	Shaff, C. D., Jr		M. M., N. Y. Central & Hudson River	Watertown, N. Y.
1908	Sharp, C. L		G. F., Okla. Cent. Ry	Purcell, Okla.
1908	Shaw, B. S.		M. M., Durham & Southern Ry	Durham, N. C.
1906	Shea, R. T.		Insp. Tools and Machy., N. Y. C. Lines.	New York City.
1903	Sheahan, J. F		M. M., Southern	Knoxville, Tenn.
1907	Shelaberger, John.		M. M., Southern Pacific Co	Bakersfield, Cal.
1899	Shepard, L. A		Atha Steel Casting Co.	Newark, N. J.
1903	Shepard, Samuel.		M. M., Minn., St. Paul & Sault Ste. Marie.	Gladstone, Mich.
1905	Shields, A.		M. M., Canadian Northern.	Winnipeg, Man., Can.
1906	Shields, H. C		Supt., Lehigh & New England	Pen Argyl, Pa.
1904	Shoemaker, H		M. M., Del., Lack. & Western	Scranton, Pa.
1906	Shreve, W. J		M. M., Minn. & Rainy River	Deer River, Minn.
1908	Siemantle, Geo.		G. M. M., Ft. Worth & Denver City R. R.	Childress, Tex.
1883	Sinclair, Angus			114 Broadway, New York City.
1900	Singer, Frank		M. M., Florence & Cripple Creek	Colorado Springs, Colo.
1892	Sinnott, W.		M. M., Baltimore & Ohio	58th st., Phila., Pa.
1889	Skinner, H. M. C.			579 Durfee st., Fall River, Mass.
1893	Slater, Frank.		M. M., Chicago & North-Western	Escanaba, Mich.
1894	Slayton, C. E.			810 North 10th street, St. Joseph, Mo.
1900	Slayton, F. T.		M. M., St. Joseph & Grand Island	St. Joseph, Mo.
1889	*Small, H. J*	1170	*G. S. M. P., Southern Pacific.*	San Francisco, Cal.
1908	Small, J. W		S. M. P., Gila Valley, Globe & Northern Ry.	Tucson, Ariz.
1903	Smith, C. B		M. E., Boston & Maine.	Boston, Mass.
1900	Smith, D. A.		M. M., Boston & Maine.	East Somerville, Mass.
1904	Smith, E. J		M. M., Atlantic Coast Line	Florence, S. C.
1893	Smith, F. B.			Indianapolis, Ind.
1896	Smith, F. C		American Locomotive Co	Providence, R. I.
1900	Smith, F. J.		D. M. M., B. & O. S. W	Washington, Ind.
1892	Smith, John L.		G. F., Pitts., Shawmut & Northern	St. Marys, Pa.
1900	Smith, L. L		M. M., Chicago & Milwaukee Electric	Highwood, Ill.
1907	Smith, M. W		M. M., Tampa & Jacksonville	Gainesville, Fla.
1899	Smith, R. D.		A. S. M., B. & A. R. R.	Boston, Mass.
1905	*Smith, R. E*	538	*G. S. M. P., Atlantic Coast Line*	*Wilmington, N. C.*
1902	Smith, Wm		Garlock Pckg. Co	New York, N. Y.
1869	Smith, W. T.		M. M., Chesapeake & Ohio	Covington, Ky.
1903	Smitham, N. L		M. M., Texas Central	Walnut Springs, Tex.
1908	Smithust, T		S. M. P. & R. S., Interoceanic Ry.	Pueblo, Mex.
1906	Smock, F. A.		M. M., P. R. R.	Jersey City, N. J.
1908	Snyder, C. A.		M. M., E. P. & S. W. R. R.	Douglas, Ariz.
1891	Soule, R. H			1571 Beacon st., Brookline, Mass.
1907	Spearman, W. J		M. M., Id. & Washington Nor. R. R.	Spirit Lake, Idaho,
1907	Sprowl, N. E.		M. M., Atlantic Coast Line	Savannah, Ga.
1901	Squire, W. C			209 Western Union Bldg., Chicago, Ill.
1898	Stansbury, C. M		M. M., Boca & Loyalton.	Loyalton, Cal.
1908	Steel, Frank.		M. M., N. Y. C. & H. R. R. R.	East Buffalo, N. Y.
1898	Stevenson, C. E.		S. M. P., Mogyana.	Campinos, San Paulo, Brazil, S. A.
1903	Stewart, A		M. S., Southern	Washington, D. C.
1906	Stewart, A. F		M. M., Chesapeake & Ohio	Clifton Forge, Va.
1906	Stewart, C. J		M. M., Central New England.	Hartford, Conn.
1900	Stewart, M. D		Fitz-Hugh Luther Co.	Chicago, Ill.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Stewart, T. R		M. M., Baltimore & Ohio	Baltimore, Md.
1890	Stillman, H		E. of T., Southern Pacific	Oakland, Cal.
1896	Stocks, W. H.			5850 Indiana ave., Chicago, Ill.
1905	Struthers, Alex		M. M., Denver, Northwestern & Pacific.	Denver, Colo.
1907	Stuart, C. M.		M. M., Philadelphia & Reading.	Tamaqua, Pa.
1890	Studer, A. L.			Iola, Kan.
1908	Stulb, W. H.		M. M., Cent. of Ga. Ry.	Savannah, Ga.
1901	Sullivan, J. J		G. M. M., Louisville & Nashville.	Birmingham, Ala.
1891 •	Summerskill, T. A			St. Albans, Vt.
1892	Sumner, Eben T.		M. M., Boston & Maine	E. Cambridge, Mass.
1899	Suzuki, S		S. M. P., Kinshui.	Moji, Japan.
1901	Swoyer, H		Rogers Locomotive Works	Paterson, N. J.
1899	Symington, T. H.			Calvert Building, Baltimore, Md.
1908	Symons, J. E.		D. M. M., Gulf, Colo. & Santa Fe Ry	Cleburne, Tex.
1892	Symons, W. E.		Pioneer Cast Steel Truck Co	Postal Telegraph Bldg. Chicago, Ill.
1883	Tandy, H.		Supt., Canadian Locomotive Works	Kingston, Ont., Can.
1896	Tawse, Robert.		Ann Arbor	Owosso, Mich.
1893	Taylor, C. M		S. M. P., Chgo., Rock Island & Pacific.	Shawnee, Okla.
1901	Taylor, H. D		S. M. P. & R. E., Phila. & Reading	Reading, Pa.
1893	Taylor, Wm. H.		M. M., N. Y., Susq. & Western	Stroudsburg, Pa.
1905	Taylor, W. M.		M. M., Thornton & Alexandria	Thornton, Ark.
1905	Temple, C. H.		M. M., Canadian Pacific	Winnipeg, Man.
1904	Terrill, C. H.		M. M., Chesapeake & Ohio	Huntington, W. Va.
1904	Thomas, E.		S. M. P., Andino Ry.	Rio Cuarto, Arg. Rep., S. A.
1908	Thomas, F. W.		Supervisor of App., A. T. & S. F. Ry.	Topeka, Kan.
1891	Thomas, H. T		M. M., Detroit & Mackinac	East Tawas, Mich.
1903	Thomas, P. G		M. M., Central R. R. of N. J	Ashley, Pa.
1892	Thomas, J. J., Jr.		M. M., Atlantic Coast Line	So. Rocky Mtn., N. C.
1901	Thomas, W. J		Christobal Shops	Canal Zone.
1890	Thompson, C. A			Morris Park, Long Island, N. Y.
1903	Thompson, E. B		A. S. M. P., Chicago & North-Western	Chicago, Ill.
1896	Thompson, Geo.		S. M. P., Denver, Northwestern & Pac	Denver, Colo.
1902	Thompson, W. O.		M. C. B., N. Y. Central & H. R. R. R	Buffalo, N. Y.
1895	Thompson, W. T.			38 Anderson place, Buffalo, N. Y.
1902	Thornton, Chas. J.		L. S., United Rys. of Havana	Havana, Cuba.
1883	Thow, Wm.		C. M. E., Government Rys	Sydney, N. S. W.
1903	Tinker, J. H.		M. M., Chicago & Eastern Illinois.	Danville, Ill.
1903	Todd, A. B.		M. M., Southern California	Richmond, Cal.
1892	Todd, Louis C		M. M., Boston & Maine	Charlestown, Mass.
1898	Tollerton, W. J.		A. G. S. M. P., Chicago, R. I. & Pacific	Chicago, Ill.
1901 •	Toltz, Max.		Manistee & Grand Rapids	Manistee, Mich.
1893	Tonge, John.		M. M., Minneapolis & St. Louis.	Minneapolis, Minn.
1907	Tonge, Thos. J		S. M. P. & R. S., Santa Fe Central	Estancia, N. M.
1903	Torrey, F. A		S. M. P., Chicago, Bur. & Quincy	Chicago, Ill.
1896	Tracy, W. L.		M. M., Louisville & Nashville	Louisville, Ky.
1892	Traver, W. H		Chicago Pneumatic Tool Co.	Chicago, Ill.
1883	Tregelles, Henry.			Care Norton, Megaw & Co., Rio de Janeiro, Brazil.
1903	Trumbull, A. G.		M. S., Erie	Cleveland, Ohio.
1890	Tuggle, S. R.		S. M. P., Houston & Texas Central	Houston, Tex.
1903	Tuma, Frank.		M. M., Erie.	Buffalo, N. Y.
1899	Turner, A.		M. M., Lehigh Valley	South Easton, Pa.
1890	Turner, Calvin G.		M. M., Phila., Balt. & Washington.	Wilmington, Del.
1906	Turner, J. A.		M. M., C. St. P. M. & O. Ry.	Itasca, Minn.
1886	Turner, J. S		Pressed Steel Car Co.	24 Broad st., N. Y. City
1890	*Turner, L. H*	189	*S. M. P., Pittsburg & Lake Erie*	*Pittsburg, Pa.*
1906	Turtle, J. A		M. M., Union Pacific.	Omaha, Neb.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1904	Uddenberg, C. E.		A. S. M. P., Swedish Government	Boden, Sweden.
1898	Van Alstyne, D.		American Locomotive Co	New York.
1905	Vanaman, C. D		M. M., Florida East Coast	St. Augustine, Fla.
1904	*Van Buskirk, H. C*	172	*S. M. P., Colorado & Southern*	*Denver, Colo.*
1896	Van Cleave, J. R.		M. M., Alaska Central	Seward, Alaska.
1904	Van Doren, G. L.		S. S., Central R. R. of New Jersey	Roselle Park, N. J.
1905	Van Ripper, D. F.		M. M., Erie	Avon, N. Y.
1891	Vauclain, Samuel M		Baldwin Locomotive Works	Philadelphia, Pa.
1898	*Vaughan, H. H.*	550	*Asst. to V. P., Canadian Pacific*	*Montreal, Can.*
1903	Vernet, C. C		S. M. P., Western Ry. of Havana	Havana, Cuba.
1892	Vogt., A. S.		M. E., Pennsylvania	Altoona, Pa.
1904	Waddington, John		Dist. Loco. Supt., Central Northern R. R.	S. Cristobal, Arg. Rep., S. A.
1904	Wagstaff, George		S. B., New York Central Lines	Buffalo, N. Y.
1905	Wahlen, John		M. M., Montpelier & Wells River	Montpelier, Vt.
1892	Waitt, A. M.			165 Broadway, New York City, N. Y.
1893	Walker, Henry E		Buenos Aires Great Southern	Buenos Ayres, Arg. Rep., S. A.
1908	Wall, G. L		M. E., Lima Loco. & Mach. Co	Lima, Ohio.
1908	Wall, H. S		M. M., Atchison, Topeka & Santa Fe.	Needles, Cal.
1904	Wallace, W. G.		Care of American Steel Foundries	Chicago, Ill.
1888	Wallis, Phillip			Hotel Roanoke, Roanoke, Va.
1900	*Walsh, F. O*	32	*M. M., A. & W. P. & W. Ry. of Ala.*	*Montgomery, Ala.*
1903	Walsh, J. F		S. M. P., Chesapeake & Ohio	Richmond, Va.
1874	Walsh, Thos		M. M., Louisville & Nashville	Howell, Ind.
1902	Walsh, W. C		M. M., Missouri Pacific	Ft. Scott, Kan.
1908	Walsh, W. F		M. M., Virginia Air Line Ry	Lindsay, Va.
1896	Walton, E. A.		S. M. P., N. Y. C. & H. R. R. R	W. Albany, N. Y.
1883	Warren, Beriah.			1619 Pennsylvania ave., St. Louis, Mo.
1882	Warren, W. B		Supt. St. L., Troy & Eastern	St. Louis, Mo.
1908	Warnock, H. P		G. F. L. D., Monongahela R. R.	Brownville, Pa.
1903	Waters, J. J.		S. M., Mex. Central	Aguiscalientes, Mex.
1906	Watkins, W. H.		M. M., Illinois Central	Water Valley, Miss.
1908	Watson, R. B		Engr. Tests, Erie R. R	Meadville, Pa.
1902	Watson, Samuel		M. M., N. Y. C. & H. R. R. R	Avis, Pa.
1904	Watters, J. H		A. M. M., Georgia	Augusta, Ga.
1883	Watts, Amos H.		M. M., Cincinnati Northern	Van Wert, Ohio.
1907	Webb, E. R.		M. M., Michigan Central	Michigan City, Ind.
1907	Weisgerber, E. L.		M. M., Baltimore & Ohio	Newark, Ohio.
1899	Weist, E. N.		M. M., Manistee & North-Eastern	Manistee, Mich.
1900	Welch, C. H.		M. M., Midland Valley	Excelsior, Ark.
1906	Wells, M. E		A. M. M., Wheeling & Lake Erie	Massillon, Ohio.
1880	*West, G. W.*	167	*S. M. P., N. Y. O. & W.*	*Middletown, N. Y.*
1903	Whale, George.		C. M. E., London & Northwestern	Crewe, England.
1907	White, Alfred		S. M., Copper River & North-Western.	Katalla, Alaska.
1885	White, A. M.		American Locomotive Co.	Manchester, N. H.
1894	White, E. T		S. M. P., Baltimore & Ohio	Mt. Clare, Baltimore, Md.
1908	White, J. E		M. M., Louisville & Nashville	Pensacola, Fla.
1901	White, W.			225 Ry. Exchange Bldg., Chicago, Ill.
1898	Whyte, F. M		C. M. E., N. Y. Central Lines	New York City.
1905	Wickhorst, M. H.		E. of T., Chicago, Burl. & Quincy.	Aurora, Ill.
1894	Wiggin, Chas. H.		S. M. P., Boston & Maine	Boston, Mass.
1878	Wightman, D. A.			Warren, R. I.
1891	Wilcox, W. J.		M. M., Mexican Central	Chihuahua, Mex.
1901	Wildin, G. W.		M. S., N. Y., New Haven & Hartford	New Haven, Conn.

JOINED.	NAME.	NO. OF LOCOS. ROAD.	ADDRESS.
1896	Williams, Alfred	Paulista Ry. Co.	Paulista, Brazil, S. A.
1905	Williams, C. R.	G. M. M., Buffalo & Susquehanna	Galeton, Pa.
1891	Williams, E. A		96 Lembeck ave., Jersey City, N. J.
1903	Williams, F. W	S. M. P., C. R. I. & G. Ry	Ft. Worth, Tex.
1905	Willius, Gustav, Jr	M. E., Great Northern	St. Paul, Minn.
1905	Wilson, Charles.	M. M., Lehigh Valley	Wilkesbarre, Pa.
1906	Wilson, D. H., Jr	Elec. Engr., Erie	Meadville, Pa.
1887	Wilson, G. F	P. A., Del., Lack. & Western	New York City.
1901	Wilson, W. H	S. M. P., Buffalo, Roch. & Pittsburg	Du Bois, Pa.
1900	Wirt, G.	M. M., C. C. C. & St. L.	Delaware, Ohio.
1900	Withers, A. B	321 Chatham ave	Rock Hill, S. C.
1907	Witherspoon, David.	G. F., Central R. R. of N. J.	Bayonne, N. J.
1906	Woodbridge, H. C.	M. M., Buffalo, Roch. & Pittsburgh	E. Salamanca, N. Y.
1903	Woodruff, S. N	M. M., Minn., St. P. & Sault Ste. Marie	Enderlin, N. D.
1903	Worsdell, Wilson	C. M. E., North-Eastern.	Gateshead-on-Tyne, Eng.
1901	Wright, R. V.	American Engineer.	285 N. 20th st., E. Orange, N. J.
1907	Wyman, R. L	M. M., Lehigh & New England	Pen Argyl, Pa.
1907	Yamamoto, Y	M. E., South Manchurian.	Tairen, Manchuria.
1908	Yeager, Thos.	M. M., Illinois Southern	Sparta, Ill.
1903	Yergens, W. F.	M. M., Erie.	Huntington, Ind.
1896	Yohn, A. E	M. M., H. & B. T. Mtn.	Saxton, Pa.
1899	York, C. C	B. A. & Pacific.	Estacion Junin, Buenos Ayres, Arg. Rep., S. A.
1907	Yoshino, M	S. M. P., South Manchurian	Tairen, Manchuria.
1902	Young, C. B.	M. E., Chicago, Burlington & Quincy	Chicago, Ill.
1908	Young, C. D	A. E. M. P., Penna. Lines West	Columbus, Ohio.
1905	Young, R. R	Repr., Southern Iron & Equip. Co.	Atlanta, Ga.
1907	Zang, P. C	M. M., N. Y., New Haven & Hartford	New Haven, Conn.
1898	Zerbee, F. J	M. M., C. C. C. & St. L.	Bellefontaine, Ohio.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1893	Baker, Geo. H.	227 Monroe st., Brooklyn, N. Y.
1898	Basford, G. M	Amer. Loco. Co., 30 Church st., New York City.
1898	Bates, E. C	Lock Box 1544, Boston, Mass.
1907	Bell, J. Snowden.	31 Nassau st., New York City.
1903	Casey, F. A	271 Franklin st., Boston, Mass.
1896	Fowler, Geo. L.	53 Broadway, New York City.
1907	Fry, Lawford H	110 Cannon st., London, E. C., Eng.
1895	Goss, W. F. M	Purdue University, Lafayette, Ind.
1889	Hill, John A	505 Pearl st., New York City.
1904	Hodgins, George	136 Liberty st. New York City.
1899	Kneass, Strickland L	Wm. Sellers Co., Ltd., Philadelphia, Pa.
1901	Lane, F. W	87 St. Nicholas place, New York
1904	Lanza, Gaetano	Mass. Inst. of Technology, Boston, Mass.
1901	Player, John	American Loco. Co., Brooks Works, Dunkirk, N. Y.
1889	Pomeroy, L. R	Safety Car Htg. & Ltg. Co., 2 Rector st., N. Y. City.
1899	Smart, R. A.	Westinghouse E. & M. Co., Pittsburgh, Pa.
1882	Smith, W. A	Manhattan Bldg., Chicago, Ill.
1899	Street, Clement F.	Westinghouse E. & M. Co., Pittsburgh, Pa.
1903	Taylor, Jos. W	390 Old Colony Bldg., Chicago, Ill.

HONORARY MEMBERS.

JOINED.	NAME	ROAD.	ADDRESS.
1885	Becker, Andrew		New Decatur, Ala.
1879	Cooke, Allen		Danville, Ill.
1869	Coolidge, G. A.		Barnard ave., Watertown, Mass.
1870	Cooper, H. L.		Chesterton, Ind.
1876	Cory, Chas. H		Lima, Ohio.
1895	Coster, E. L.	Residence, Irvington-on-Hudson	Broad Exchange Bldg., 25 Broad st., N. Y. City.
1870	Divine, J. F.	Atlantic Coast Line.	Wilmington, N. C.
1881	Eastman, A. G		Sutton, Que.
1869	Elliott, Henry		East St. Louis, Ill.
1881	Ennis, W. C.		Passaic, N. J.
1872	Foss, J. M	Central Vermont	St. Albans, Vt.
1885	Galloway, A.	C. H. & D.	Cincinnati, Ohio.
1871	Hewitt, John.		1323 So. Jefferson st., St. Louis, Mo.
1874	Jeffery, E. T	Denver & Rio Grande	Denver, Colo.
1868	Johan, Jacob		Springfield, Ill.
1868	Kinsey, J. I	Lehigh Valley	Easton, Pa.
1878	Maglenn, Jas.	Seaboard Air Line.	Raleigh, N. C.
1869	McKenna, John		2005 N. Alabama ave., Indianapolis, Ind.
1888	Medway, John.		7 Hawthorne ave., Troy, N. Y.
1871	Miles, F. B.	Bement & Miles	Philadelphia, Pa.
1885	Paxson, L. B	Philadelphia & Reading	Reading, Pa.
1878	Pilsbury, Amos		Portland, Me.
1874	Place, T. W.		Waterloo, Iowa.
1881	Player, John		319 Franklin ave., River Forest, Ill.
1887	Rhodes, Godfrey W.		Westbaugh, Pontefract, Yorkshire, England.
1869	Richards, George		14 Auburn st., Roxbury, Mass.
1870	Robinson, W. A		Hamilton, Ont.
1874	Schlacks, Henry		Denver, Colo.
1869	Sellers, Morris.		Western Union Bldg., Chicago, Ill
1869	Setchel, J. H		Cuba, N. Y.
1891	Sheer, J. M.		514 7th st., East St. Louis, Ill.
1888	Sheppard, F. L	Pennsylvania.	Altoona, Pa.
1868	Sprague, H. N.		Jamestown, N. Y.
1875	Strode, Jas.		Elmira, N. Y.
1883	Sullivan, A. W	Illinois Central.	Chicago, Ill.
1883	Thomas, W. H		4230 Spruce st., Philadelphia, Pa.
1869	Thompson, John.		51 Lakewood Road, Newton Highlands, Mass.
1870	Towne, H. A		54 S. 3d st., Minneapolis, Minn.
1883	Twombly, F. M.		5 Westville st., Dorchester, Mass.
1868	Wells, Reuben.		Paterson, N. J.

PROCEEDINGS.

MONDAY'S SESSION.

The President, Mr. William McIntosh, of the Central Railroad of New Jersey, called the meeting to order at 9:30 o'clock and said:

Will the Past Presidents of both the Master Car Builders' Association and the Master Mechanics' Association, the President of the Master Car Builders' Association and the members of the Executive Committee of the Master Mechanics' Association come forward and take seats on the platform?

Mr. J. H. Setchel invoked the Divine blessing.

THE PRESIDENT: Mayor Franklin P. Stoy has kindly consented to welcome us to his fair city. [Applause.]

MAYOR F. P. STOY: Mr. Chairman, Ladies and Members of the American Railway Master Mechanics' Association: If there is one thing that I love, especially when the thermometer is sporting around the eighties, it is to march behind a band. [Laughter and applause.] I remember last year telling the members of this Association that if they would return to our city we would certainly give them a warm time. Now, with the weather we have provided for you and the little heat that has been turned on, I believe you recognize I have been keeping my word.

It is a pleasure, ladies and gentlemen, to be here this morning, to bid you welcome to the city, to offer you the freedom of the city. While it is perhaps a little late, nevertheless I should feel very much aggrieved if you should leave the town unless I

saw this organization in a body and had the opportunity of extending it an individual welcome.

The other part of this institution collectively, as you come here, have had their welcome. They have had all extended to them that they needed, I presume; at least I found it so in some cases. [Laughter.] When I extended the freedom to the delegations I expected that they would enjoy themselves to their most hearty content. Now, while they have all these good sunshiny days and moonlight nights and have enjoyed themselves to a great extent, I want to say, I will again call to your minds that the people of Atlantic City will do better next year if you will promise to come back.

I understand that the space that has been supplied by your organizations here has been somewhat extended over last year, and we appreciate the presence of this Association perhaps more than any that come to our shore, and I assure you the people in general all over the city look forward to these occasions as much as you do. It is a benefit to us, and I told the delegation at the last meeting it certainly must be a great benefit to you.

I thank you, Mr. President, for this occasion. I trust that you will observe that our hotel fraternity is doing all it can to bring this institution to Atlantic City again, and I certainly will heartily coöperate with them, and we believe, as we are going along year after year, if you choose to come back that we may make it a little hotter for you. [Laughter.]

With these few words, Mr. President, I hope to meet you not only individually again but collectively. [Applause.]

The President: I will call on our ex-President, Mr. J. F. Deems, to respond to the remarks of Mayor Stoy.

Mr. Deems: Mr. President, Mayor Stoy, Ladies and Gentlemen — I feel myself, this morning, in a rather embarrassing position when called upon to perform this duty, owing to the fact that by contrast with the work done by my friend, Mr. Eugene Chamberlin, at the Master Car Builders' convention, I know that I must suffer greatly. I won't attempt to go into any of the beautiful rhetoric that he did about the huckleberries and the jimpson weeds clinging around the door, and all that

sort of thing — it is all right, I guess. [Laughter.] This occasion brings to my mind a story that I heard some time, some place, in some way, about an occasion when Daniel Webster was engaged in a debate in Congress. One of those who were opposing him happened to notice that Mr. Webster had fallen asleep, said to a gentleman as he was rising to speak, that Mr. Webster was asleep: like a flash, the answer came back, "For God's sake, don't wake him up." So if Mr. Chamberlin is here and is asleep, don't wake him up. Inasmuch as he had the freedom of the city last night it is within the range of at least a remote possibility that he is not very much awake. I hope so at any rate. [Laughter.]

I was speaking about the freedom of the city, whatever that is. I understand there have been some misgivings in the minds of Mayor Stoy and his associates about extending the freedom of the city to the Master Mechanics. It seemed all right as far as the Master Car Builders were concerned, because with that nestor of the Master Car Builders' Association, Mr. Chamberlin, as a chaperon, they felt that everything would be conducted properly. But they were not quite so sure about the Master Mechanics. Another question that has come up in connection with this subject, is whether the freedom of the city includes the freedom of Egg Harbor. That, I think, will be one of the very strong inducements to get the Convention to come back here again next year, from what I hear about it.

I will say that for one I feel that Atlantic City has done herself proud. I believe that I voice the sentiments of most of the members of both conventions when I say that. I think that I can say, and in doing so, express the sentiments of nearly all of them, that we feel that Atlantic City has done very well by us, and we thank them sincerely for their kindness and especially Mayor Stoy for the kindness that he has shown us in many ways; and I hope that it may be thought desirable to come back again next year, and I am sure if they can extend the freedom of Egg Harbor along with Atlantic City there will be very little doubt about our returning. I hope they can make such an arrangement.

I thank Mayor Stoy and Atlantic City for their kindness.

President McIntosh then presented his annual address.

To the Members of the Association and Friends:

Officially and personally I welcome you to the forty-first annual convention of this Association, which has already covered the span of the active life of man and which is ready for its best and most efficient work. You need no word of mine to stimulate or inspire your efforts, but let me entreat you all to remember that because of the greatness of the problems before us, because of the monumental work that is behind us, much is expected of us for the future, and we must make this, and every convention which is to come, more effective than any that have gone before.

Let us remember that this Association has seen the small problem grow to be one of the very greatest problems faced by man. Think a moment of the locomotives and trains, the ships, the bridges, the tunnels, the buildings, the cities which we knew as children; think of them again as they have grown to the present state. Statistics are not needed to show that we have a man's task before us. A gray hair or two that speaks of experience is the authority upon which we place before those who are to take our places the rule of life that will be most greatly needed in the future.

Without question, our greatest problem is that of the selection, treatment and organization of men. The recent years of abnormal business activity have brought to the surface the slumbering tendency of organized labor to drift away from harmonious relations with employers and array itself on the side of the radical and demagogue, who seek notoriety and selfish advancement in creating and fostering discord between employers and employees whose every interest are identical. We know that any attempt on the part of either to operate independently must result disastrously. The demagogue and the radical lay great stress on the instances where some few in financial and commercial lines have overstepped the boundaries of correct business methods, and these would-be reformers, in their rampant enthusiasm, would destroy the whole business structure, and invite railroad employees to participate in the movement, under the vague proposition that in some mysterious way they would be benefited by the catastrophe.

The sovereign remedy is lower tariffs, in the face of low rates and already large reductions from natural causes, and other embarrassment of the railroads with class legislation and impracticable laws, confiscatory in scope and surrounded with political red tape, that would largely increase operating expenses and further reduce earnings. How can employees expect to be benefited by such complications? Their interests are so closely allied with the interests of the company they serve that they must be proportionately affected by reduced earnings. There is no magic way of escaping. The laws that govern are immutable.

The points of issue between railroad companies and their employees are usually few in number and easy of solution. Wages are at present generally satisfactory, and only questions of methods conflict. Mechanics, especially machinists, are reluctant to adopt other than hourly rates of pay, while

manufacturers and corporations are in favor of some system of fixed output, profit-sharing or piece work. The men claim, and with some grounds for their contention, that they have frequently been treated unfairly where piece work has been adopted. This was often owing to bad judgment on the part of local officials in their efforts to adjust piece-work prices that had been established at unreasonably high figures, as a result of the adoption of hurriedly prepared piece-work schedules, or perhaps no schedule at all, merely guessing at prices and then arbitrarily putting them in force. On the other hand, workmen have interfered with normal results by restricting the output, under the mistaken idea that they would benefit thereby. Abnormal rates are bound to result from such methods, and dissatisfaction and protests from the workmen follow, for no matter how fairly and carefully these adjustments are made, the workmen are naturally suspicious that some advantage is being taken of them. It is evident, therefore, that the establishment of piece-work prices should be arranged with the utmost care and deliberation. It must further be borne in mind that agreements to be enduring and stand the test of time should be agreeable to both parties interested, and that due consideration should be given the workmen's side of the question, in order to insure this result. Fairly adjusted piece-work rates should prove advantageous to the workmen, enabling them to earn much better wages with but little greater physical effort, only requiring closer mental application and attention to details on their part, while the manufacturers and corporations would be the gainers by having their tools and machinery working at all times to their full capacity.

The only one to suffer under the stipulated output system is the indifferent and lazy workman. There should be no place in the ranks of honest railroad mechanics, nor in the membership list of labor organizations, for the dissolute floater, inefficient imposter and agitator, who demands the highest rate of pay for the smallest return, by him, in labor and its products, giving most of his time and energy to sowing seeds of discord among his fellow workers, seeking to make himself a leader in his organization and always in bitter opposition to the independent workman who prefers to win increased compensation and promotion upon his merits.

There is another kind of workman, however, who should be welcome to both the companies and the unions. He would first be a citizen of good repute, or at least had declared his intention to become a citizen; he should be a good mechanic — his union demands that; he would be a man of good habits — his union requires that, too; he would do an honest day's work, seeing that the tools and machines entrusted to his care were properly handled, and that the latter were always working to their full capacity, and that his employer's interests would be advanced in every way possible. An organization founded on such principles would require no coercion to obtain membership and its members would not be seeking employment, for they would always be in demand. I am confident there is not a member of this Association who would not be glad to secure the services of such men.

In my railroad experience, extending over forty years of active service in different departments and various branches of railroad work, much of the time in charge of large bodies of workmen, I can not recall an instance where it has not been possible to adjust any of the ordinary differences that arise by free and frank discussion of the questions at issue with the men affected. I, therefore, think the average railroad employee is too intelligent to be led very far astray by scheming politicians or unwise agitators. They must keep in mind that their own and their families' interests are bound up with the company they serve, and that they can not prosper when the company does not. No doubt they have grown up in the service, and their fathers before them. Many of the present officials have been advanced from their ranks and there should be no reason why they, too, should not become officials in due time. Then why should they combine with those who would embarrass the company, when their every interest is with it and against such a proposition? Officials and workmen should join hands and stand shoulder to shoulder against this common enemy and resist, by every honest means, its efforts to handicap their prosperity. One year ago there were approximately one million six hundred thousand railroad employees in this country, and their influence prevails wherever civilization and commerce extends. Their efforts unitedly directed to protect the railroads from unjust attack would exert such restraint upon the radical, of whatever class, as to cause him to stop and consider and modify his actions to conform to fair dealing and the interests and wishes of those employed by the companies, and depending upon their success for support for themselves and their families. The folly of workmen assisting in directly or indirectly curtailing the earning capacity of the railroads, and at the same time expecting to continue to draw the liberal wages they were receiving when earnings were good, is about as ridiculous as the tailor to expect golden eggs after he had killed the goose that laid them.

My honored predecessor pleaded eloquently for a man. He said, "We have inherited. What shall we bequeath?" Yes, we want many men, both in command and in the ranks. Wise men, strong men in their respective lines, reasonable men and independent men, who would respect the rights of others as readily as they would contend for their own. We must have young men qualifying themselves for advancement, young men with patience and determination to work up, step by step, to the most important positions. It should not be necessary to seek beyond their ranks for selections to fill positions that become vacant. There should be a waiting list of men available. Each of us who now occupy official positions should have his own successor selected, so far as it is possible to prepare and qualify him by training for the position.

No doubt we do not know our men as well as we should, and while it may be impossible to gather this intimate knowledge directly, we can accomplish much by gathering indirect information and keeping systematic records. We perhaps are not training our young men as thoroughly as we

should, and to accomplish this result we need the coöperation of managing officials. This will no doubt be forthcoming on proper presentation of feasible plans, as is evidenced by the hearty support given recent liberal methods of training apprentices, now being introduced on several railroads, and which promises to be much farther reaching in satisfactory results than its earlier promoters dared to hope for. Equally liberal inducements, carefully worked out for other departments, would no doubt bring about similar results and well repay the effort. It may not be out of place to mention here that all of our propositions and plans for better conditions will come to naught without the sincere help of those who control the financial affairs of large enterprises.

We require more than men. We need an organization. An organization that develops men; develops them broadly and quickly. We need men of all kinds — leaders and followers. The followers are most important, for if we develop the followers the leaders appear automatically, and consequently take care of themselves.

Let us note for a moment the careful training given young men in many lines of business to qualify them for important positions awaiting — and railroad work is not less important. One of the prominent transatlantic lines has just commissioned a substantial ship for training purposes, and from which will be graduated recruits for the fleet, and in the line of recent experience by railroad companies of the difficulty of securing reliable help, perhaps the time is now propitious for them to take action of the kind suggested, adopting some such system of education, training and promotion that will first induce promising young men to take up employment, then educate and train them in the line of their duties, finally opening up to them a line of promotion that will encourage them to remain permanently in the service and eliminate the growing tendency that now exists of employees seeking other employment as soon as they have gathered an outline of the duties they are expected to perform. Certainly well prepared young men are worth as much to the railroads as they are to other industries to which they are attracted.

It seems fitting to sum up what the man who must assume our duties and responsibilities must be prepared to do. He must prepare himself for leadership by efficient service in subordinate places. He must know men. He must help in building up an organization of men. It is a mistake to always seek genius; it is more important to build up that combination of various abilities, capabilities and temperaments which will form a united, homogeneous body before which the difficulties of the greatest problems will crumble and disappear. We should all strive to build up a working organism which shall be so complete and so satisfactory and with a correct policy so firmly established that those who follow can find little which they will be willing to change or to discard.

It is my earnest hope that I have, in a modest way, brought to your attention a few salient facts that may be suggestive of further and deeper thought along the path outlined, to the end that we may have concerted

action in the direction indicated by him whom we all love, Burns, when he pointed out that we are leading steadily, though slowly, to that goal

"Where man to man the world o'er,
Will brothers be and a' that."

As president of this Association I attended the recent conference of State governors which assembled last month at the White House, by invitation of the President, for a discussion of means for the conservation of the resources of the country. Once before, one hundred and twenty-two years ago, President Washington called the State governors together, that time to consider the "Development of Natural Resources."

After a little more than a century the development in some directions seems to have been too rapid, leading to wastefulness, and it is clear that our resources must be husbanded.

Before the Master Mechanics' and Master Car Builders' Associations lie a great responsibility in that we represent an enormous consumption of natural resources. To be faithful to our trusts we must, therefore, use every effort to carry out the spirit which led to the recent conference.

"Conservation of Resources" was the object of the assemblage at Washington. This suggested to my mind the thought of conservation of energy as applied to the problem before the railroad officials of this country. I wish to suggest a thought which is not new, but is, in my judgment, becoming more important every day. My suggestion, briefly stated, is that sooner or later the energies of mechanical officers of railways must be conserved by the concentration of every effort. Sooner or later the Master Mechanics' and Master Car Builders' Associations must be consolidated into one powerful, united, representative organization. Let me place this proposition squarely before you by expressing the opinion that the progress of the times, the conditions of our work and the character of our problems demand this step. I will not presume to outline how this should be brought about, but I most earnestly recommend that the Executive Committee be instructed to raise the question with the Executive Committee of the Master Car Builders' Association and consider ways and means looking toward such consolidation, which I believe, if we are true to the interests which we represent, must not be long deferred.

I can not close this address without expressing thanks — which sentiment I am sure is endorsed by the Association — to the supply men who are responsible for the wonderful display of railroad machinery and appliances, the greatest ever assembled outside of the world's fairs at Chicago and St. Louis; also to that splendid body of business men of Atlantic City — those hustlers whose coöperation has made it possible.

The following members registered:

Adams, A. C.	Allen, C. W.	Appler, A. B.
Aldcorn, Thos.	Allison, W. L.	Arp, W. C.
Allen, G. S.	Amann, W. E.	Atkinson, R.

Ayers, A. R.

Barton, T. F.
Basford, G. M.
Bechhold, H. G.
Bell, J. Snowden.
Bentley, H. T.
Bingaman, C. A.
Bissett, J. R.
Boldridge, R. M.
Booth, J. S.
Bowles, C. K.
Bradeen, J. O.
Branch, G. E.
Brangs, P. H.
Brazier, F. W.
Bronner, E. D.
Brown, H. B.
Buchanan, A., Jr.
Bushmeyer, C. J.
Bussing, G. H.

Caracristi, V. Z.
Carroll, J. T.
Casey, F. A.
Cassidy, D. E.
Chamberlin, E.
Chambers, C. E.
Chambers, J. S.
Chase, F. A.
Chester, W. E.
Chidley, Joseph.
Christopher, J.
Chrysler, W. P.
Clark, F. H.
Clark, J. H.
Clifford, J. G.
Cole, T. J.
Conners, J. J.
Connolly, J. J.
Cook, J. S.
Cook, T. R.
Cooper, F. R.
Cory, C. H.
Coutant, M. R.
Crawford, D. F.
Cromwell, O. C.
Cross, C. W.
Cullinan, John.
Cumback, R. O.
Curtis, T. H.

Davis, D. E.
Deeter, D. H.
Desmond, D. G.
DeVoy, J. F.
Dewey, J. J.
Dickerson, S. K.
Diehr, C. P.
Dillon, S. J.
Divine, J. F.
Dolan, S. M.
Dunn, A. J.
Dunn, J. F.

Edmonds, G. S.
Edmondson, W. G.
Elden, Edward.
Elliott, J. B.
Ennis, W. C.
Ettinger, R. L.
Evans, R. C.
Ewing, J. J.
Feeley, T. M.
Ferguson, L. B.
Fetner, W. H.
Fildes, Thomas.
Flavin, J. T.
Flory, B. P.
Fogg, J. W.
Forsyth, William.
Foster, O. M.
Fowler, G. L.
Franey, M. D.
Fraps, J. C.
Fuller, C. E.
Fulmer, J. H.

Gaines, F. F.
Gallagher, G. A.
Gauthier, J.
Gilbert, E. B.
Gilbert, F. M.
Gordon, H. D.
Goss, W. F. M.
Gould, J. E.
Gray, G. M.
Graham, Charles.
Gray, B. H.
Green, H.
Greenwood, B. E.
Griffith, R.
Gurry, George.

Hainen, J.
Hair, J.
Hammond, G. O.
Hancock, G. A.
Harrigan, P. J.
Harris, C. M.
Harris, J. D.
Harrington, H. H.
Haskell, B.
Hartigan, B.
Hawkins, B. H.
Hayes, C. W.
Hess, G. F.
Henderson, G. R.
Hibbits, F. N.
Hicks, I. C.
Hildreth, F. F.
Hill, J. A.
Hill, John.
Hill, Rufus.
Hinckley, A. C.
Hodgins, George.
Hogan, C. H.
Hoffmaster, F. S.
Howard, John.
Hunter, H. S.
Hyndman, F. T.

James, Charles.
Jennings, Thomas.
Johnson, W. O.
Joughins, G. R.

Kalbaugh, I. N.

Kapp, W. F.
Kastlin, Jacob.
Keegan, J. E.
Kehoe, R. H.
Kellogg, W. L.
Kells, Willard.
Kendig, R. B.
Kinney, W. H.
Kilpatrick, J. B.
Kirkpatrick, James.
Kilpatrick, R. F.
Kneass, S. L.
Knight, W. E.
Kurman, A. G.
Kyle, C.

Lanza, G.
Lane, F. W.
Lape, C. F.
Leach, H. L.
Lewis, W. H.
Leach, W. B.
Lovell, A.
Luscombe, J. T.

MacBain, D. R.
McGill, A. M.
McGee, G. S.
McGee, W. J.
McHaffie, A. B.
McHattie, T.
McIntosh, William.
McLean, W. J.
McNaughton, James.
McNulty, F. M.
McRae, J. A.
Machesney, A. G.
Magarvey, J. R.
Maher, P.
Malthaner, W.
Manchester, A. E.
Manchester, H. C.
Manning, J. H.
Mechling, J. E.
Meister, C. L.
Mellin, C. J.
Mendenhall, C. M.
Menzell, W. G.
Meredith, H. P.
Miller, E. A.
Miller, J. B.
Minshull, P. H.
Mitchell, A. E.
Miller, S. W.
Moan, E. G.
Moir, William.
Monkhouse, H.
Montgomery, H.
Montgomery, William.
Moriarty, G. A.
Morris, W. S.
Muhlfeld, J. E.
Murrian, W. S.

Nelson, E. D.
New, W. E.
Neward, F. H.
Newhouse, J. F.

Ord, C. R.
Oviatt, H. C.
Owens, W. H.

Parish, L. G.
Parks, G. E.
Park, S. T.
Passmore, H. E.
Patterson, J. S.
Paxton, Thomas.
Pearce, J. S.
Pearsall, D. M.
Peyton, H. T.
Peck, P. H.
Pflager, H. M.
Phillips, C.
Pilcher, J. A.
Platt, J. G.
Pomeroy, L. R.
Powers, M. J.
Pratt, E. W.
Prendergast, A. P.
Prendergast, J. F.
Preston, Robert.

Quereau, C. H.
Quigley, Joseph.

Redding, D. J.
Reid, W. L.
Rieckman, W. H.
Rettew, C. E.
Reynolds, O. H.
Rhodes, L. B.
Richmond, W. H.
Riley, G. N.
Robinson, Frank.
Rogers, R. H.
Roope, Thomas.
Rosing, W. H. V.
Rumney, Thomas.
Russell, W. B.
Ryan, J. J.

Sanderson, R. P. C.
Scheffer, F. H.
Schlafge, William.
Seabrook, C. H.
Seddon, C. W.
Sedgwick, E. V.
Seidell, G. W.
Seley, C. A.
Setchel, J. H.
Shepard, L. A.
Shea, R. T.
Shoemaker, H.
Sinclair, Angus.
Sinnott, W.
Small, H. J.
Small, J. W.
Smethust, T.
Smith, C. B.
Smith, E. J.
Smith, F. C.
Smith, William.
Smith, W. T.
Smock, F. A.
Sprowl, N. E.
Squire, W. C.

Stewart, A.
Stewart, A. F.
Stewart, C. J.
Stuart, C. M.
Stewart, T. R.
Street, C. F.
Stocks, W. H.
Stulb, W. H.
Symington, T. H.

Taylor, C. M.
Taylor, J. W.
Thomas, F. W.
Thomas, H. T.
Thomas, J. G.
Thomas, J. J., Jr.
Thomas, W. H.
Thompson, E. B.
Tollerton, W. J.
Tracy, W. L.
Tuma, Frank.
Turnbull, A. C.
Turner, J. S.

Van Doren, G. L.
Van Ripper, D. F.
Vauclain, S. M.

Wagstaff, George.
Wahlen, John.
Wall, G. L.
Walsh, F. O.
Walsh, J. F.
Walton, E. A.
Watson, R. B.
Watts, A. H.
Weisgerber, E. L.
West, G. W.
White, A. M.
White, E. T.
White, J. E.
Wickhorst, M. H.
Wildin, G. W.
Williams, F. W.
Wilson, D. H.
Wirt, G.
Witherspoon, David.
Wright, R. V.
Wyman, R. L.

Yeager, Thomas.
Young, C. B.
Young, C. D.

THE PRESIDENT: The next business will be the approval of the minutes of the last meeting. As these minutes have been printed, and have been before you for some time, I presume it is unnecessary to read them, and unless there are objections offered, we will consider them approved. They are approved.

The next business is the report of the Secretary and Treasurer.

SECRETARY'S REPORT.

To the President and Executive Committee of the American Railway Master Mechanics' Association:

In accordance with the usual custom at our annual convention, I append herewith statement showing the membership of the Association and receipts and expenditures during the year just closed:

ACTIVE MEMBERSHIP.

Membership, June, 1907		819
Transferred to honorary membership	2	
Deaths	4	
Resignations	8	
Dropped, nonpayment of dues and mail returned	18	
		32
		787

New members during the year	74	
Reinstated	1	
		75
Total membership		862

ASSOCIATE MEMBERSHIP.

Membership, June, 1907	17	
Elected, June, 1907	2	
		19

HONORARY MEMBERSHIP.

Membership, June, 1907	36	
Transferred from Active	2	
		38
Deaths		1
Total membership		37

TOTAL MEMBERSHIP.

Active	862
Associate	19
Honorary	37
Total	918

At the convention of 1907 Messrs. H. Elliott and W. C. Ennis were transferred to honorary membership.

During the year the following resignations were received:

Active members: F. J. Leigh, C. H. Barnes, Wm. Miller, Georges Collin, J. W. Marden, Marcel Japiot, M. R. Davis and John McGie.

The following deaths have been recorded:

Active members: E. Ryan, L. M. Kidd, O. Stewart and Jas. Macbeth.

Honorary members: M. N. Forney.

The following names have been taken from the list of members because of nonpayment of dues or on account of their mail being returned:

Active members: E. M. Lake, L. L. Dawson, T. S. Inge, Jno. H. Vought, Louis Wellisch, Maurice Hickey, F. A. Given, P. T. Dunlop, J. W. Cross, F. G. Brownell, M. D. Brown, C. A. Brann, J. J. Bayley, W. H. Young, H. K. Mudd, J. Mayne Nicholls, John Whetstone and A. A. Hube.

At the convention of 1907 Messrs. Lawford H. Fry and J. Snowden Bell were elected to associate membership.

The following is a list of members added to the roll during the year:

George Siemantel, G. M. M., Fort Worth & Denver City Ry., Childress, Tex.

J. W. Small, S. M. P., Sonora Ry., Tucson, Ariz.

E. L. Moser, Chief Draftsman, Phila. & Reading Ry., Reading, Pa.

T. Smethurst, S. M. P., Interoceanic Ry., Puebla, Mexico.

J. E. Symons, D. M. M., Gulf, Colo. & Santa Fe Ry., Cleburne, Tex.

J. F. Fairbank, M. M., Malvern & Freeco Valley Ry., Malvern, Ark.

K. L. Dresser, M. M., Chicago, Cincinnati & Louisville R. R., Peru, Ind.

T. W. McCarthy, M. M., C. R. I. & P. Ry., Argenta, Ark.

E. G. Brooks, M. M., Mobile & Ohio R. R., Whistler, Ala.

C. H. Osborne, M. M., C. & N.-W. Ry., Baraboo, Wis.

H. R. Warnock, G. F. L. D., Monongahela R. R., Brownsville, Pa.

F. W. Thomas, Supervisor of Apprentices, A. T. & S. F. Ry., Topeka, Kan.

Charles D. Young, A. E. M. P., Penna. Lines, Columbus, Ohio.

Thomas R. Cook, A. E. M. P., Penna. Lines, Ft. Wayne, Ind.

G. L. Wall, M. E., Lima Loco. & Mach. Co., Lima, Ohio.

J. E. Mechling, M. M., Vandalia R. R., Terre Haute, Ind.

A. Dinan, M. M., Kansas City Belt Ry., Kansas City, Mo.

E. G. Moan, Gen. Foreman, A. C. L. R. R., Waycross, Ga.

R. C. Evans, S. M. P., Western Maryland R. R., Hagerstown, Md.

C. M. Fritsch, M. M., Western Maryland R R., Hagerstown, Md.

R. H. Kehoe, M. M., Norfolk & Southern Ry., New Bern, N. C.

T. M. Neel, Jr., M. E., Atlanta, Birmingham & Atlantic, Fitzgerald, Ga.

F. S. Hoffmaster, A. M. M., N. Y. P. & N. Ry., Cape Charles, Va.

O. M. Foster, M. M., L. S. & M. S. Ry., Elkhart, Ind.

Theo. Larrey, M. M., Interoceanic Ry., Jalapa, Vera Cruz, Mex.

H. P. Meredith, A. E. M. P., Penna. R. R., Altoona, Pa.

L. A. Petrie, M. M., Oahu Ry. & Land Co., Honolulu, T. H.

W. J. McCammon, Loco. Supt., Mex. So. Ry., Puebla, Mex.

Thos. Yeager, M. M., Ill. So. Ry., Sparta, Ill.

A. C. Russell, M. M., Inter-California Ry., Hanlon Junction, Cal.

E. L. Weisgerber, Retired M. M., Balt. & Ohio R. R., Newark, Ohio.

William Henry, Asst. M. M., St. L. & S. F. Ry., Memphis, Tenn.

A. G. Kurman, M. M., Mt. Jewett, Kinzua & Riterville R. R., Kushequa, Pa.

A. W. Hayes, M. M., Blue Ridge Ry., Anderson, S. C.

R. E. Osborn, M. M., Williamsville, Greenville & St. Louis Ry., Greenville, Mo.

C. E. Foyle, M. M., Susquehanna & New York R. R., Towanda, Pa.

W. C. A. Henry, S. M. P., Penna. Lines, Columbus, Ohio.

Alfred White, Supt. Mach., Copper River & Northwestern Ry., Katalla, Alaska.

S. Hatah, Chief Supt. M. P., Imperial Government Rys., Tokio, Japan.

H. Iwasaki, Traffic Mgr., Imperial Government Rys., Tokio, Japan.

Y. Yamamoto, M. E., South Manchurian Rys., Tairen, Manchuria.

M. Yoshino, S. M. P., South Manchurian Rys., Tairen, Manchuria.

Roland Finch, Tech. Repr., Beyer, Peacock & Co., Yokohama, Japan.
Geo. P. Goodrich, M. M., Ft. S. & W. Ry., Ft. Smith, Ark.
A. E. Yohn, M. M., Huntingdon & Broad Top Mtn. Ry., Saxton, Pa.
G. W. Lillie, S. C. D., St. L. & S. F. Ry., St. Louis, Mo.
W. L. Larry, M. M., N. Y. N. H. & H. R. R., Taunton, Mass.
A. R. Ayers, Supt. Shops, L. S. & M. S. Ry., Elkhart, Ind.
John T. Carroll, Asst. Supt. Shops, L. S. & M. S. Ry., Collinwood, Ohio.
A. P. Prendergast, M. M., Balt. & Ohio R. R., Baltimore, Md.
J. W. Evens, M. M., Ala. Gt. So. Ry., Birmingham, Ala.
R. L. Wyman, M. M., L. & N. E. R. R., Pen Argyl, Pa.
G. W. Cooper, M. M., Mexican Central Ry., Aguascalientes, Mex.
W. H. Rieckman, A. M. M., Boston & Maine R. R., Mechanicsville, N. Y.
P. C. Zang, M. M., N. Y. N. H. & H. R. R., Providence, R. I.
H. A. Macbeth, M. M., N. Y. C. & St. L. Ry., Conneaut, Ohio.
R. T. Jaynes, M. M., Lehigh & Hudson River Ry., Warwick, N. Y.
E. R. Webb, M. M., Mich. Cent. R. R., Michigan City, Ind.
C. M. Harris, M. M., The Washington Term. Ry., Washington, D. C.
J. P. Dorsey, D. M. M., B. & O. R. R., Parkersburg, W. Va.
A. H. Hodges, D. M. M., B. & O. R. R., Cumberland, Md.
C. P. Diehr, M. M., N. Y. C. & H. R. R. R., Jersey Shore, Pa.
M. W. Smith, M. M., Tampa & Jacksonville, Ry., Gainesville, Fla.
James Hocking, M. M., N. Y. N. H. & H. R. R., Norwood Central, Mass.
E. E. Herr, Engine House Foreman, Penna. R. R., Camden, N. J.
N. E. Sprowl, M. M., A. C. L. R. R., Savannah, Ga.
George Moll, M. M., P. & R. Ry., Reading, Pa.
J. L. Prendergast, M. M., Balt. & Ohio R. R., Glenwood, Pa.
T. J. Tonge, S. M. P., Santa Fe Cent. Ry., Estancia, N. M.
J. H. Fulmor, M. M., Penna. R. R., Pottsville, Pa.
H. C. Oviatt, M. M., N. Y. N. H. & H. R. R., New Haven, Conn.
C. D. Shaff, Jr., M. M., N. Y. C. Lines, Watertown, N. Y.
L. A. Richardson, M. M., C. R. I. & P. Ry., Trenton, Mo.

REINSTATED.

F. P. Barnes, M. M., Denver & Rio Grande R. R., Grand Junction, Colo.

RECEIPTS.

To dues collected from members	$3,725.00
" sale of Proceedings	1,075.33
" Ryerson Scholarship Fund	400.00
	$5,200.33

EXPENSES.

Paid	exchange	$ 16.95
"	expenses convention, 1907	64.25
"	stamps and stamped envelopes	255.00
"	office supplies and expenses	123.58
"	printing	2,097.54
"	expenses, committees	49.75
"	express	15.34
"	blue-prints, tracings	19.00
"	salary, Secretary	1,500.00
"	reporting convention, 1907	209.30
"	office rent	202.08
"	surety bond, Secretary	7.20
"	zinc cuts, etc	42.54
"	Ryerson Scholarship	500.00
"	telephone and telegraph service	36.58
"	balance remitted to Treasurer	61.22
		$5,200.33

The bills against the Association have been paid except for the preparation of some of the reports which were printed after the books were closed.

The unpaid dues amount to $1,440.00.

A statement showing the members in arrears for dues and the amount thereof is presented herewith for the information of the members, amounting to $1,440.00.

A detailed statement of the dues collected during the year is herewith appended and made part of the report.

DETAILED STATEMENT OF DUES COLLECTED FROM MEMBERS.

1907.			
June	15	J. W. Addis	$ 5.00
"	16	T. F. Barton	5.00
"	11	G. S. Allen	5.00
"	15	G. M. Basford	5.00
"	13	J. O. Bradeen	5.00
"	12	G. E. Branch	5.00
"	13	David Brown	5.00
"	13	W. A. Brown	5.00
"	13	J. E. Chambers	5.00
"	12	Jos. Chidley	5.00
		Carried forward	$ 50.00

		Brought forward	$ 50.00
June	13	F. C. Cleaver	5.00
"	15	Wm. Cockfield	5.00
"	11	L. L. Collier	5.00
"	13	J. J. Conners	5.00
"	12	F. R. Cooper	5.00
"	12	D. H. Deeter	5.00
"	12	C. H. Delaney	5.00
"	12	S. J. Dillon	5.00
"	12	S. M. Dolan	5.00
"	11	W. H. Dooley	10.00
		Carried forward	$ 105.00

Brought forward ......$		105.00
June 12	J. F. Enright...	5.00
" 12	T. M. Feeley...	5.00
" 11	W. H. Fetner...	10.00
" 12	This. Fildes ...	5.00
" 12	M. D. Franey...	5.00
" 11	Thos. Fraser ...	5.00
" 12	C. E. Fuller....	5.00
" 13	J. Gauthier	5.00
" 12	Jno. Gill	5.00
" 14	Geo. Gilmour ..	5.00
" 12	Jas. Graham, Jr.	5.00
" 12	Geo. Gurry	5.00
" 11	J. Hainen	5.00
" 12	F. J. Harrison..	5.00
" 13	P. J. Hickey....	5.00
" 13	Jno Hill.	5.00
" 12	W. H. Hill.....	5.00
" 11	A. C. Hinckley..	5.00
" 16	C. H. Hogan....	5.00
" 11	A. W. Horsey..	5.00
" 16	Jno. Howard....	5.00
" 14	H. S. Hunter...	5.00
" 13	T. J. Hennessey	5.00
" 14	Jacob Kastlin ..	5.00
" 14	W. [illegible] Kellogg..	5.00
" 12	Willard Kells ..	5.00
" 12	J. B. Kilpatrick.	5.00
" 12	R. F. Kilpatrick.	5.00
" 11	C. Kyle	5.00
" 13	T. D. Mannion..	5.00
" 12	M. J. McCarthy.	5.00
" 13	A. B. McHaffie.	5.00
" 12	C. J. Mellin.....	5.00
" 11	G. A. Miller....	5.00
" 13	P. H. Minshull..	5.00
" 18	H. Montgomery.	5.00
" 13	J. H. Murphy...	5.00
" 11	W S. Murrian..	5.00
" 12	J. F. Newhouse.	5.00
" 14	J. E. O'Hearne..	5.00
" 12	C. Phillips	5.00
" 14	J. A. Pilcher...	5.00
" 12	M. J. Powers...	5.00
Carried forward ......$		325.00

Brought forward ......$		325.00
June 14	C. H. Quereau..	5.00
" 11	C. E. Rettew....	5.00
" 12	A. H. Reynolds.	5.00
" 16	C. W. Seddon..	5.00
" 12	H. Shoemaker ..	5.00
" 18	O. Stewart	5.00
" 12	C. M. Stuart....	5.00
" 12	E. T. Sumner..	5.00
" 12	D. A. Smith....	5.00
" 12	C. H. Terrell...	5.00
" 19	W. H. Thomas..	5.00
" 12	L. C. Todd.....	5.00
" 11	W. J. Tollerton.	5.00
" 14	Jno. Tonge	5.00
" 15	A. Turner......	5.00
" 13	G. L. Van Doren	5.00
" 14	Geo. Wagstaff..	5.00
" 12	Jno. Wahlen ...	5.00
" 11	W. G. Wallace..	5.00
" 12	E. A. Walton...	5.00
" 13	B. Warren	5.00
" 11	J. H. Waters...	5.00
" 12	G. Wirt	5.00
" 14	E. L. Weisgerber	5.00
" 14	E. T. White....	5.00
" 10	F. L. Bates.....	10.00
" 10	G. W. Mudd....	5.00
" 21	P. G. Baker....	10.00
" 22	W. S. Grandy..	5.00
" 8	W. Malthaner .	5.00
" 8	J. E. Cannon...	15.00
" 8	Wm. Kelly	5.00
" 8	A. B. Withers..	5.00
" 8	F. Slater	5.00
" 8	C. H. Davis....	5.00
" 8	C. L. Aiken....	5.00
" 8	J. W. Oplinger.	5.00
" 8	C. J. Bushmeyer	5.00
" 12	W. J. Thomas..	5.00
" 13	F. W. Williams.	10.00
" 12	J. S. Bissett....	5.00
" 13	B. E. Greenwood	5.00
" 14	F. F. Hildreth..	5.00
Carried forward ......$		565.00

Brought forward		......$	565.00
June	14	W. May	5.00
"	26	John Hopwood..	5.00
"	26	E. S. Hume....	5.00
"	26	M. R. Davis....	5.00
"	26	John Neville ...	5.00
"	18	Wm. Henry ...	5.00
"	18	Y. Yamamato ..	5.00
"	18	M. Yoshino	5.00
"	14	W. L. Larry....	5.00
"	13	A. R. Ayers....	5.00
"	13	J. T. Carroll....	5.00
"	13	A. P. Prendergast	5.00
"	13	R. L. Wyman..	5.00
"	13	G. W. Cooper..	5.00
"	13	W. H. Rieckmann	5.00
"	13	P. C. Zang.....	5.00
"	13	H. A. Macbeth.	5.00
"	12	E. R. Webb....	5.00
"	12	J. P. Dorsey....	5.00
"	12	A. H. Hodges..	5.00
"	12	M. W. Smith...	5.00
"	12	James Hocking..	5.00
"	12	E. E. Herr.....	5.00
"	12	N. E. Sprawl...	5.00
"	12	Geo. Moll	5.00
"	12	J. L. Prendergast	5.00
"	14	T. J. Tonge....	5.00
"	14	J. H. Fulmor...	5.00
"	14	H. C. Oviatt....	5.00
"	29	H. E. Passmore	5.00
"	29	P. T. Lonergan.	5.00
"	29	John Waddington	5.00
July	5	Robt. Quayle....	5.00
"	5	S. P. Bush......	5.00
"	5	H. T. Bentley..	5.00
"	5	S. M. Vauclain.	5.00
"	5	A. B. Johnson..	5.00
"	5	W. H. Collins..	5.00
"	5	A. M. Waitt....	5.00
"	5	W. F. M. Goss.	5.00
Carried forward		......$	765.00

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Brought forward		......$	765.00
July	5	R. H. Rogers...	10.00
"	5	F. Hedley	5.00
"	5	H. N. Curry....	5.00
"	5	J. J. Ellis......	5.00
"	5	Thos. Marshall.	5.00
"	5	Wm. O'Herin ..	5.00
"	5	Geo. A. Hancock	5.00
"	5	H. S. Hayward.	5.00
"	5	P. H. Peck.....	5.00
"	5	F. T. Casaneve.	5.00
"	5	S. L. Kneass...	5.00
"	5	L. Pfafflin	5.00
"	5	Wm. Garstang..	5.00
"	5	G. M. Gray.....	5.00
"	5	W. H. Nuttall..	5.00
"	5	A. E. Manchester	5.00
"	5	W. T. Thompson	5.00
"	5	J. E. Keegan...	5.00
"	5	W. B. Warren..	5.00
"	5	Thos. Aldcorn ..	5.00
"	5	L. H. Turner...	5.00
"	5	J. S. Turner....	5.00
"	5	L. R. Pomeroy..	5.00
"	5	C. H. Howard..	5.00
"	5	R. B. Kendig...	5.00
"	5	W. E. Symons..	5.00
"	5	S. F. Prince, Jr.	5.00
"	5	W. S. Morris...	5.00
"	5	Philip Wallis ...	5.00
"	5	A. G. Leonard..	5.00
"	5	W. T. Fitzgerald	5.00
"	5	M. E. Wells....	5.00
"	5	W. C. Arp......	5.00
"	5	J. G. Neuffer...	5.00
"	5	H. M. Pflager..	5.00
"	5	G. W. Lillie....	5.00
"	5	J. P. McCuen..	5.00
"	5	J. R. Magarvey.	5.00
"	5	G. N. Riley.....	5.00
"	5	L. D. Gillett....	5.00
"	5	G. K. Hatz.....	5.00
"	5	Harry Ashton ..	5.00
"	5	F. B. Barclay...	5.00
Carried forward		......$	985.00

Brought forward			$ 985.00
July	5	W. H. V. Rosing	5.00
"	5	W. H. Taylor..	5.00
"	5	R. P. Blake....	10.00
"	5	H. M. Carson..	5.00
"	5	Geo. S. Hodgins	5.00
"	5	Samuel Higgins.	5.00
"	5	E. V. Sedgwick.	5.00
"	5	W. S. Hancock.	5.00
"	5	J. J. Ewing....	5.00
"	5	W. O. Thompson	5.00
"	5	G. W. Wildin...	5.00
"	5	E. M. Herr....	5.00
"	5	H. H. Vaughan.	5.00
"	5	G. Lanza	5.00
"	5	J. D. Harris....	5.00
"	5	J. C. Homer....	10.00
"	5	Tracy Lyon	5.00
"	5	Jas. McNaughten	5.00
"	5	W. H. Hufman.	5.00
"	5	F. F. Gaines....	5.00
"	5	G. E. Parks....	5.00
"	5	W. J. Schlacks..	5.00
"	5	H. A. Lyddon..	5.00
"	5	E. B. Thompson	5.00
"	5	R. T. Jaynes....	5.00
"	5	H. B. Ayers....	5.00
"	5	L. B. Ferguson.	5.00
"	5	A. E. Yohn.....	5.00
"	5	R. H. Soule....	5.00
"	5	A. J. Dunn.....	5.00
"	5	C. B. Royal.....	5.00
"	5	L. S. Randolph..	5.00
"	5	J. A. Hill.......	5.00
"	5	A. B. Appler....	5.00
"	5	W. L. Ried.....	5.00
"	27	Max Goodrich..	5.00
"	27	W. C. Burel....	5.00
"	27	Wm. Renshaw..	5.00
"	27	J. N. Mowery...	5.00
"	27	P. H. Murphy..	5.00
"	27	F. J. Smith.....	5.00
"	27	C. H. Seabrook.	5.00
"	27	H. B. Hunt.....	5.00
Carried forward			$1,219.00

Brought forward			$1,210.00
July	27	F. H. Scheffer..	5.00
"	27	A. Shields	5.00
"	27	F. M. Pierce....	5.00
"	27	H. S. Bryan....	5.00
"	27	J. W. Fogg.....	5.00
"	27	C. A. Seley.....	5.00
"	27	W. N. Best.....	5.00
"	27	Angus Sinclair..	5.00
"	27	W. H. Watkins.	5.00
"	27	O. A. Fisher....	5.00
"	27	J. J. Ryan......	5.00
"	27	R. D. Smith....	5.00
"	27	J. W. Cloud....	5.00
"	27	Geo. Whale	5.00
"	27	S. K. Dickerson	5.00
"	27	M. C. Dinkel...	5.00
"	27	H. T. Thomas..	5.00
"	27	J. F. Dunn......	5.00
"	27	LeGrand Parish	5.00
"	27	H. J. Small.....	5.00
"	27	R. E. McCuen..	5.00
"	27	W. F. Kapp....	5.00
"	27	A. L. Humphrey	5.00
"	27	F. O. Walsh....	5.00
"	27	W. C. Squire...	5.00
"	27	R. O. Cumback.	5.00
"	27	P. Maher	5.00
"	27	W. J. Shreeve..	5.00
"	27	T. A. Brown..	5.00
"	27	F. E. Davisson..	5.00
"	27	H. N. Breneman	5.00
"	27	W. L. Austin...	5.00
"	27	Wm. Buchanan.	5.00
"	27	T. S. Lloyd.....	5.00
"	27	Geo. Gibbs	5.00
"	27	A. Forsyth	5.00
"	27	John Mackenzie.	5.00
"	27	J. L. Greatsinger	5.00
"	27	T. E. Keyworth	5.00
"	27	J. J. Monohan..	5.00
"	27	J. F. Walsh....	5.00
"	27	T. A. Lawes....	5.00
"	27	H. F. Ball......	5.00
Carried forward			$1,425.00

		Brought forward	$1,425.00
July	27	H. A. Gillis....	5.00
"	27	W. H. Marshall	5.00
"	27	D. J. Justice....	5.00
"	27	W. B. Russell..	5.00
"	27	B. H. Gray.....	5.00
"	27	J. E. Chisholm..	5.00
"	27	J. H. Pennington	10.00
"	27	A. C. Adams...	5.00
"	27	Thos. Paxton...	5.00
"	27	G. L. Fowler...	5.00
"	27	A. C. Russell...	5.00
"	27	P. M. Hammett	5.00
"	27	H. H. Harrington	5.00
"	27	T. W. Demarest	5.00
"	27	D. J. Durrell...	5.00
"	27	M. G. Bock.....	5.00
"	27	W. G. Menzel..	5.00
"	27	D. E. Davis....	5.00
"	27	W. H. Stocks...	5.00
"	27	J. W. Records..	5.00
"	27	J. B. Morgan...	5.00
"	27	Jas. Milliken ...	15.00
"	27	L. B. Rhodes...	5.00
"	27	J. E. Goodman..	5.00
"	27	J. A. Graham...	5.00
"	27	S. T. Park.....	5.00
"	27	J. S. Cook......	5.00
"	27	B. Haskell	5.00
"	27	G. R. Joughins..	5.00
"	27	R. E. Smith....	5.00
"	27	J. K. Brassill...	5.00
"	27	G. T. Neubert..	5.00
"	27	J. A. Egan.....	5.00
"	27	A. Stewart	5.00
"	27	F. A. Torrey ...	5.00
"	27	F. A. Chase....	5.00
"	27	J. E. Muhlfeld..	5.00
"	27	C. M. Harris...	5.00
"	27	H. L. Leach....	5.00
"	27	J. T. Hayes.....	5.00
"	27	T. A. Foque....	5.00
"	27	R. A. Billingham	5.00
"	27	W. H. Wilson..	5.00
		Carried forward	$1,655.00

		Brought forward	$1,655.00
July	27	E. F. Needham..	5.00
"	27	L. L. Bentley...	5.00
"	27	Geo. James	5.00
"	27	T. W. Heintzleman	5.00
"	27	F. M. McNulty.	5.00
"	27	A. E. Mitchell..	5.00
"	27	J. B. Barnes....	5.00
"	27	J. H. Clark.....	5.00
"	27	A. H. Watts....	5.00
"	27	F. P. Roesch...	5.00
"	27	P. J. Harrigan..	5.00
"	27	J. B. Elliott....	5.00
"	27	A. B. Minton...	5.00
"	27	J. H. Manning..	5.00
"	27	W. L. Gilmore..	5.00
"	27	C. J. Stewart...	5.00
"	27	C. K. Bowles...	10.00
"	27	C. D. Vanaman.	5.00
"	27	E. D. Bronner..	5.00
"	27	H. T. Herr.....	5.00
"	27	F. M. Whyte...	5.00
"	27	F. M. Gilbert...	5.00
"	27	G. W. West....	5.00
"	27	J. E Sague.....	5.00
"	27	J. C. Fraps.....	5.00
"	27	F. W. Brazier..	5.00
"	27	D. J. Redding..	5.00
"	27	J. S. Bell.......	5.00
"	27	J. J. Conolly....	5.00
"	27	A. W. Lord....	5.00
"	27	R. T. Shea.....	5.00
"	27	H. Monkhouse..	5.00
"	27	F. A. Delano...	5.00
"	27	R. J. Grass.....	5.00
"	27	Wm. McIntosh..	5.00
"	27	D. B. Cargo....	5.00
"	27	F. J. Cole......	5.00
"	27	J. C. Little.....	5.00
"	27	R. L. Ettenger..	5.00
"	27	G. L. Dickson..	5.00
"	27	Wm. Jennings..	5.00
"	27	G. A. Moriarty..	5.00
		Carried forward	$1,870.00

	Brought forward	......$1,870.00	
July	27	R. P. C. Sanderson	10.00
"	27	John Hair	5.00
"	27	M. R. Coutant..	5.00
"	27	Thos. Roope ...	5.00
"	27	E. J. Smith.....	5.00
"	27	J. E. Gould.....	5.00
"	27	W. W. Atterbury	5.00
"	27	C. E. Gossett...	5.00
"	27	D. O'Leary	5.00
"	27	D. Van Alstyne.	5.00
"	27	T. H. Symington	5.00
"	27	A. W. Gibbs....	5.00
"	27	A. S. Vogt.....	5.00
"	27	E. D. Nelson...	5.00
"	27	F. J. Zerbee....	5.00
Aug.	7	C. H. Wiggin..	5.00
"	7	A. White	5.00
"	7	J. E. Irwin.....	5.00
"	7	L. A. Shepard..	5.00
"	7	J. J. Waters....	5.00
"	7	W. L. Kellogg..	5.00
"	7	W. R. McKeen, Jr.	5.00
"	7	T. E. Adams...	5.00
"	7	Geo. Collin	5.00
"	7	Geo. Asselin ...	5.00
"	7	J. C. Glass......	5.00
"	7	J. T. McGrath..	5.00
"	7	D. W. Ford....	5.00
"	7	J. P. Nolan....	5.00
"	7	T. B. Purves, Jr.	5.00
"	7	L. H. Fry......	5.00
"	7	R. M. Boldridge	5.00
"	7	G. R. Bennett...	5.00
"	7	L. A. Richardson	5.00
"	7	C. M. Babcock..	5.00
"	7	D. A. Wightman	5.00
"	7	G. J. Churchward	5.00
"	7	J. A. McRae....	5.00
"	7	W. H. Richmond	5.00
"	7	W. F. Bradley..	5.00
"	7	F. T. Slayton...	5.00
	Carried forward	......$2,080.00	

	Brought forward	......$2,080.00	
Aug.	7	G. R. Henderson	5.00
"	7	C. J. Thornton..	5.00
"	7	W. H. Brehm..	5.00
"	7	J. A. Carney....	5.00
"	7	H. Emerson ...	5.00
"	7	J. W. Harkom..	5.00
"	7	Wm. Worsdell..	5.00
"	7	E. W. Burgis...	5.00
"	7	W. E. Dunham.	5.00
"	7	R. Preston......	5.00
"	7	E. Marshall	5.00
"	7	J. J. Sullivan...	5.00
"	7	W. M. Taylor..	5.00
"	7	A. F. Stewart...	5.00
"	7	W. C. Hayes...	5.00
"	7	W. A. Smith...	5.00
"	10	A. J. Cota......	5.00
"	10	C. D. Hilferty..	5.00
"	10	I. W. Fowle....	5.00
"	10	Jno. Horrigan..	5.00
"	10	J. E. Cameron..	5.00
"	10	C. M. Mendenhall	5.00
"	10	E. B. Gilbert...	5.00
"	10	C. F. Baker....	5.00
"	27	W. H. Traver..	5.00
"	27	W. E. Chester..	5.00
"	27	D. F. Crawford.	5.00
"	27	Geo. Thompson.	5.00
"	27	F. A. Casey....	5.00
"	27	Maynard Robinson	5.00
"	26	E. Elden	5.00
"	26	C. M. Muchnic..	5.00
"	26	L. S. Kinnaird..	5.00
"	26	E. E. Davis....	5.00
"	26	W. F. Dixon...	5.00
"	26	C. B. Young....	5.00
"	26	P. G. Thomas..	5.00
"	26	Bert Hartigan..	5.00
"	26	W. O. Johnson.	15.00
"	26	J. W. Hill......	5.00
"	26	G. H. Bussing..	5.00
"	26	S. Phipps.......	5.00
	Carried forward	......$2,300.00	

Brought forward		......	$2,300.00
Aug.	26	John Shelaberger	5.00
"	26	F. H. Neward..	5.00
"	26	J. McLean	5.00
"	26	P. D. Park.....	15.00
"	26	H. C. Van Buskirk	5.00
"	26	R. H. Briggs...	5.00
"	26	C. A. Bingaman	5.00
"	26	John McNamara	5.00
"	26	E. Ryan	5.00
"	26	J. M. Robb.....	5.00
"	26	J. S. Booth.....	5.00
"	26	G. S. McKee...	5.00
"	26	W. B. Robb....	5.00
"	26	Thos. Millen ...	5.00
"	26	J. R. Morrison..	5.00
"	26	H. L. Hobbs....	5.00
"	26	T. H. Curtis....	5.00
"	26	A. McCormick..	5.00
"	26	G. S. Hunter...	5.00
"	26	R. N. Durborow	5.00
"	26	G. W. French..	5.00
Sept.	12	H. Iwasaki	5.00
"	12	S. Hatah	5.00
"	25	C. E. Foyle....	5.00
Oct.	9	J. R. Gould....	5.00
"	9	C. P. Diehr....	5.00
"	9	J. S. Albright...	5.00
"	9	Wm. Forsyth ..	5.00
"	9	C. R. Ord......	5.00
"	9	G. H. Baker....	5.00
"	9	Manuel Elordi..	10.00
"	9	R. Moran	5.00
"	9	E. A. Miller....	5.00
"	9	W. T. Smith....	5.00
"	9	R. Griffith	5.00
"	9	E. S. Marshall..	5.00
"	9	R. V. Wright...	5.00
"	9	J. H. McConnell	5.00
"	9	J. J. Casey.....	5.00
"	9	Henry Bartlett..	5.00
"	9	Henry Fowler..	5.00
"	9	D. E. Cassidy...	5.00
Carried forward		......	$2,525.00

Brought forward		......	$2,525.00
Oct.	9	A. L. Studer...	5.00
"	9	A. Lovell	5.00
"	9	C. F. Street....	5.00
"	9	H. B. Hawe....	5.00
"	9	J. G. De Silva Friere	5.00
"	9	P. D. Plank....	5.00
"	9	Wm. Schlafge ..	5.00
"	9	W. H. Lewis...	5.00
"	9	Alex. Kearney..	[illegible].00
"	9	G. A. Gallagher.	5.00
"	9	C. W. Cross....	5.00
"	9	A. J. Fries.....	5.00
"	9	H. P. Durham..	5.00
"	9	T. W. Macfarlane	5.00
"	9	G. A. Ferguson..	5.00
"	9	W. E. Amann..	5.00
"	9	L. C. Noble.....	5.00
"	9	Ben Johnson ...	5.00
"	9	F. Monlaverdo..	10.00
"	9	A. M. White....	5.00
"	9	Owen Clark ...	5.00
"	9	W. C. A. Henry	5.00
"	15	F. G. Ferguson.	5.00
"	15	C. W. Stevenson	5.00
"	15	H. Tregelles ...	5.00
"	18	H. M. C. Skinner	5.00
"	18	J. R. Van Cleve	5.00
"	18	W. D. Holland..	5.00
"	18	W. Cross	5.00
"	18	J. S. Chambers .	5.00
"	18	A. Bardsley .	5.00
"	28	T. S. Beauclerk.	5.00
"	28	Harry Pearse ..	5.00
"	28	L. Greaven	5.00
"	28	J. B. Michael...	5.00
"	28	R. E. Osborne..	5.00
Nov.	18	Jas. Marchbanks	5.00
"	18	F. H. Litton....	5.00
"	18	I. N. Kalbaugh..	5.00
"	18	W. E. Knight...	5.00
"	18	R. A. Smart....	5.00
Carried forward		......	$2,735.00

Brought forward		......	$2,735.00
Nov.	18	E. C. Bates.....	5.00
"	18	R. H. Johnson..	5.00
"	18	C. W. Hayes...	5.00
"	23	M. J. Drury....	5.00
"	23	H. D. Gordon...	5.00
"	27	A. J. Kurman...	5.00
"	27	C. R. Williams..	5.00
"	27	R. J. Goodale...	5.00
"	29	H. G. Bechhold.	5.00
Dec.	6	J. F. Deems....	5.00
"	6	F. T. Hyndman.	5.00
"	21	W. Sinnott......	5.00
"	21	A. G. Machesney	5.00
"	21	J. G. Platt.....	5.00
"	21	B. P. Flory....	5.00
Jan.	1	M. H. Wickhorst	5.00
"	1	Richard English	5.00
"	1	J. A. Turner...	5.00
"	1	Jas. Fitzmorris..	5.00
"	1	W. I. McCammon	20.00
"	6	A. B. Adams...	5.00
"	6	F. G. Benjamin.	5.00
"	23	D. Witherspoon.	5.00
"	23	Wm. Thow	10.00
"	23	A. W. Lord	5.00
"	23	H. L. Aldana...	5.00
"	23	H. Stillman	5.00
"	23	Oscar Antz	5.00
"	23	W. J. Haynen...	5.00
"	23	Theo. Larrey...	5.00
"	27	W. H. Russell..	5.00
"	27	O. M. Foster...	5.00
Feb.	3	W. S. Gallaway.	5.00
"	3	P. T. Rusch....	5.00
"	3	T. Sakuma	5.00
"	3	F. B. Smith....	5.00
"	7	B. D. Lockwood	10.00
"	11	Harry Pearse ..	5.00
"	11	T. S. Beauclerk.	5.00
"	11	H. P. Meredith.	5.00
"	11	L. A. Petries...	5.00
"	11	F. S. Hoffmaster	5.00
Carried forward		......	$2,970.00

Brought forward		......	$2,970.00
Feb.	13	W. A. Nettleton	5.00
"	20	C. L. Meister...	5.00
"	20	W. H. Hamilton	5.00
"	20	H. G. Hudson..	5.00
"	20	C. J. McMasters	5.00
"	24	Thos. Booth ...	5.00
"	24	Jas. Buchanan...	5.00
Mar.	6	E. G. Moan....	5.00
"	11	C. F. Chase....	5.00
"	11	W. S. Clarkson.	5.00
"	11	W. L. Harrison.	5.00
"	11	S. J. Delaney...	5.00
"	11	D. G. Desmond..	5.00
"	11	A. C. Deverell..	5.00
"	11	J. B. Miller.....	5.00
"	11	J. T. Flavin....	5.00
"	11	B. H. Hawkins..	5.00
"	11	Samuel Shepard	5.00
"	11	W. B. Leach...	5.00
"	11	W. G. Edmonson	5.00
"	11	J. H. Maysilles.	5.00
"	11	Geo. H. Hodgins	5.00
"	11	Geo. Dickson ..	5.00
"	11	J. Kirkpatrick...	5.00
"	11	H. W. Hibbard.	5.00
"	11	Wm. Hassman..	5.00
"	11	M. K. Barnum..	5.00
"	11	Wm. Augustus..	5.00
"	11	J. S. Patterson..	5.00
"	11	F. Mertsheimer.	5.00
"	19	F. A. Smock....	5.00
"	19	J. Potton	5.00
"	19	G. H. Haselton..	5.00
"	19	C. H. Prescott..	5.00
"	19	Jno. Dickson ...	5.00
"	19	C. F. Baker....	5.00
"	19	C. M. Hoffman.	5.00
"	19	Samuel Watson.	5.00
"	19	T. McHattie ...	5.00
"	19	Chas. Wilson ..	10.00
"	19	C. M. Taylor...	5.00
"	19	John Medway ..	5.00
"	21	R. M. McDougall	5.00
Carried forward		......	$3.190.00

	Brought forward	......$3,190.00	
Mar.	21	W. J. Wilcox...	10.00
"	21	S. L. Blair......	10.00
"	21	J. T. McGrath..	5.00
"	21	Frank Singer ..	5.00
"	21	S. W. Miller....	5.00
"	21	J. H. Rice......	5.00
"	21	F. H. Clark....	5.00
"	21	M. S. Monroe..	5.00
"	28	G. L. Wall.....	5.00
Apr.	17	J. I. Krauss....	5.00
"	17	C. G. Turner...	5.00
"	17	L. L. Collier....	5.00
"	17	F. J. Leigh.....	5.00
"	17	F. E. Place.....	5.00
"	17	Max Toltz	5.00
"	17	L. L. Smith.....	10.00
"	17	V. U. Powell...	10.00
"	17	Rufus Hill	5.00
"	17	C. M. Stansbury ·	5.00
"	17	E. N. Weist....	5.00
"	17	Jas. McDonough	5.00
"	17	F. W. Williams.	5.00
"	17	D. W. Cunningham	5.00
"	17	R. R. Young ...	5.00
"	17	A. B. Todd.....	5.00
"	17	G. H. Emerson..	5.00
"	17	C. H. Barnes...	5.00
"	17	J. Christopher..	5.00
"	17	A. L. Moler....	5.00
"	18	Wm. Moir	5.00
"	18	Geo. B. Nutt...	5.00
"	24	C. J. Bushmeyer	5.00
"	24	J. L. Smith.....	5.00
"	24	W. J. Bennett..	5.00
"	24	Theo. Laurent..	5.00
"	24	J. F. De Voy...	5.00
"	24	Arthur Dinan ..	5.00
"	24	Wilbur Green ..	5.00
"	24	W. P. Hobson..	5.00
May	1	Thos. Yeager...	5.00
"	1	S. Phipps	5.00
"	2	T. W. McCarthy	5.00
	Carried forward	......$3,420.00	

	Brought forward	......$3,420.00	
May	9	J. E. Symons...	5.00
"	9	T. Smithhurst..	20.00
"	9	G. P. Goodrich..	5.00
"	12	G. A. Gallagher.	10.00
"	12	J. R. Groves....	5.00
"	12	H. C. Manchester	5.00
"	12	I. C. Hicks.....	5.00
"	12	Thos. Rumney..	5.00
"	12	N. W. Sample..	5.00
"	12	Wm. Kelly	10.00
"	12	W. L. Tracy....	5.00
"	12	J. W. Balderston	5.00
"	12	R. Finch	10.00
"	12	Alfred Williams	15.00
"	12	Harry Pollitt ..	15.00
"	23	J. Piccioli......	5.00
"	23	C. T. Noyes....	5.00
"	23	W. T. Foster...	5.00
"	23	Frank Robinson	5.00
"	23	W. Montgomery	5.00
"	23	C. W. Lee......	5.00
"	23	J. G. Clifford...	5.00
"	23	O. A. Fisher....	5.00
"	23	E. Thomas	10.00
"	23	J. M. Dow......	5.00
"	23	D. J. Mullen....	5.00
"	23	J. P. Dolan.....	5.00
"	23	D. M. Pearsall..	5.00
"	23	C. A. Thompson	5.00
"	23	J. W. Small....	5.00
"	23	J. S. Pearce....	5.00
"	23	T. F. Brady....	5.00
"	23	J. A. Gibson....	5.00
June	6	A. Buchanan, Jr.	10.00
"	6	D. Clark	10.00
"	6	F. M. Fryburg..	5.00
"	6	C. C. York......	10.00
"	6	R. D. Hawkins.	5.00
"	6	E. Chamberlin..	5.00
"	6	A. G. Turnbull.	5.00
"	6	Frank Tuma ...	5.00
"	6	W. G. Wallace..	5.00
"	6	Robt. Gould ...	5.00
	Carried forward	......$3,705.00	

Brought forward		$3,705.00
June 6	P. H. Brangs	5.00
" 6	D. F. Van Ripper	5.00
Carried forward		$3,715.00

Brought forward		$3,715.00
June 6	Thos. Walsh	5.00
" 6	C. S. Hall	5.00
Total		$3,725.00

SCHOLARSHIPS.

In regard to the scholarships at Stevens Institute of Technology, during the past college year Mr. R. W. Pritchard was the only student attending. He graduated this year, so that all four scholarships are now vacant.

The scholarship at Purdue University is filled by Mr. H. A. Houston, who is now in his second year term.

JOS. W. TAYLOR,
Secretary.

TREASURER'S REPORT.

June 11, 1907, balance on hand	$1,739.11
June 16, 1907, received from Secretary	38.14
June 11, 1908, coupons on mortgage bond, Jerome Wheelock	40.00
Interest on deposits to June, 1908	34.30
Balance in bank, June 16, 1908	$1,851.55
Received from Secretary, June 21, 1908	61.22
	$1,912.77

Also on hand bond of the Mortgage Bond Company, No. 212, at four per cent, for $1,000.

NEW YORK, June 16, 1908.

THE PRESIDENT: Gentlemen, you have heard the report of the Secretary and the Treasurer; what action will you take?

MR. P. H. PECK: I move that the reports of the Secretary and Treasurer be received and referred to the Auditing Committee. (Carried.)

THE SECRETARY: At the meeting of the Executive Committee held last evening, it was agreed to recommend that the annual dues for the present year should be fixed the same as last year at $5.

THE PRESIDENT: Gentlemen, you have heard the report of the Secretary as to the action taken by the Executive Committee regarding the annual dues. What action will you take?

MR. T. H. CURTIS: I move that the action of the Executive Committee be approved. (Motion seconded and carried.)

THE PRESIDENT: The next business in order is the election of an Auditing Committee of three members. Let us have recommendations for this committee. Who shall they be?

The following gentlemen were nominated for members of the Auditing Committee: L. R. Pomeroy, J. W. Fogg and C. H. Snyder.

On motion the nominations were closed and the Secretary was authorized to cast the ballot for the election of these gentlemen as the Auditing Committee, which was done.

THE PRESIDENT: The next order of business is unfinished business.

THE SECRETARY: There is nothing under the head of unfinished business.

THE PRESIDENT: We will now proceed to new business.

THE SECRETARY: As has been the custom for several years, I invited the Traveling Engineers' Association to have a representative present at this meeting. I have a letter from Mr. W. O. Thompson, Secretary, notifying me of the appointment of Mr. W. J. Hurley, of the New York Central, who is also a Past President of the Traveling Engineers' Association.

MR. G. W. WILDIN: I move that we extend to Mr. Hurley the privileges of the floor as the representative of the Traveling Engineers' Association. (Motion carried.)

THE PRESIDENT: Mr. Hurley, we are pleased to extend to you the privileges of the floor at this convention.

MR. HURLEY: Mr. President, and Gentlemen: I thank you on behalf of the Traveling Engineers' Association for the privileges of the floor. [Applause.]

THE SECRETARY: Mr. President, at the meeting last evening of the Executive Committee, the application of Mr. John Med-

way for honorary membership was considered and was ordered submitted to the convention with the approval of the Executive Committee. Mr. Medway has been a member of the Association since the year 1888.

THE PRESIDENT: Gentlemen, you have heard the recommendation of the Executive Committee in regard to making Mr. John Medway an honorary member of this Association.

MR. F. F. GAINES: I move that the recommendation of the Executive Committee be approved and that Mr. Medway be made an honorary member of this Association.

(Motion seconded and carried.)

THE SECRETARY: The application of Mr. W. H. Thomas, formerly Superintendent of Motive Power of the Southern Railway, is submitted by the Executive Committee for life membership. Mr. Thomas has been a member of the Association since 1883.

MR. PRESIDENT: What action will you take on this application?

MR. J. H. SETCHEL: I move that Mr. Thomas be made an honorary member of this Association.

Motion seconded and carried.

THE SECRETARY: Mr. John Player, formerly Superintendent of Motive Power of the Atchison Road, asks to be made an honorary member of the Association. This application meets with the approval of the Executive Committee. He has been a member of the Association since 1881.

THE PRESIDENT: What action will you take on this application?

MR. P. H. PECK: I move that Mr. Player be made an honorary member of this Association.

Motion seconded and carried.

THE SECRETARY: Mr. President, I have the proposal of Prof. Edward G. Schmidt, Associate Professor of Railway Engineering of the University of Illinois, for Associate Membership in the Association.

The proposal is signed by Messrs. C. B. Young, M. K. Barnum and LeGrand Parish. This is a notice which, under our rules, will have to lie over until the next annual convention.

The President has appointed the following Committee on Correspondence and Resolutions: Messrs. G. M. Basford, L. R. Pomeroy and A. E. Mitchell.

On Obituaries: M. N. Forney, A. Sinclair; E. Ryan, George W. Butcher; L. M. Kidd, Ben Johnson; O. Stewart, A. Montgomery; James Macbeth, A. M. Waitt.

THE PRESIDENT: Gentlemen, we have now arrived at the discussion of reports. The first one in order is on "Mechanical Stokers." I think, gentlemen, we can expedite the work materially if it is understood when these reports are read, that they are received. It does not require a motion. We simply accept the reports unless there is objection. It will then further save time if we all keep closely to the subject and not wander away too far, and at the conclusion of the discussion, when the proper time comes to close, let some one who has been following closely take that action. Is Mr. Garstang here to read this report? Is Mr. Hodgins here? Mr. Walsh, will you read it?

(The report of the committee was presented by Mr. J. F. Walsh, C. & O. Ry.)

REPORT OF COMMITTEE ON MECHANICAL STOKERS.

To the Members:

The mechanical stokers used on locomotives in this country up to the present time have at least demonstrated the fact that freight and passenger engines, in road service, can be successfully fired by mechanical means. Mechanical stoking, however, has not made much progress abroad. In reply to an inquiry on this subject, Mr. G. J. Churchward, Chief Superintendent of the Locomotive, Carriage and Wagon Department of the Great Western Railway of England, says: "We have tried some mechanical stokers, but with our lump coal and the amount per mile we use, neither of the appliances I have yet seen has any prospect of superseding hand firing. Our average consumption per engine mile over the whole railway is only about 40 pounds."

Your committee is advised that some experiments are now being made with an underfeed type of locomotive stoker, and other forms are also undergoing experiments on various railroads throughout the

country, and in presenting this progress report, your committee, while acknowledging its indebtedness to those who have kindly communicated the results of stoker trials, yet feels that the data so far available has not been sufficiently conclusive to warrant its being formally presented to the Association.

Stokers concerning which your committee have been able to obtain some information since the 1907 convention are the Victor (formerly the Day-Kincade), the Crosby, Hayden and the Strouse types. It may be observed that the Day-Kincade stoker originated on the Chesapeake & Ohio Railroad and the earliest experiments with this device were made on that road. The following descriptions and illustrations of the above devices have been compiled chiefly from accounts published at various times in the columns of *Railway and Locomotive Engineering,* and they are inserted in this report for the general information of the members of the Association.

VICTOR MECHANICAL STOKER.

The Victor stoker consists of a coal hopper which stands on a frame. The frame, which is attached to the boiler and is supported upon three small wheels, stands on the foot plate of the locomotive. Underneath the hopper is a steam cylinder placed horizontally, which operates a ram or plunger for throwing coal into the fire-box. This may be called the plunger engine in order to readily distinguish it. Under the hopper and at the forward end, placed crosswise, is a small reciprocating engine which operates the valve of the plunger engine and it also keeps a pair of conveyor screws in motion. (See Fig. 1.)

The conveyor screws lie along the bottom of the coal hopper, one on each side, and their motion is effected by the rotation of their shafts by ratchets, pawls being attached to a lever with connection rod, actuated by the small reciprocating engine. Coal thrown into the hopper by the fireman is thus constantly worked forward and delivered on the stoking plate in front of the ram.

The reciprocating movement of the ram or plunger is the same as piston of the plunger engine which drives it. This piston is driven forward by live steam pressure, but it makes, in regular order, what may be called a rapid, medium and slow stroke according to the amount of steam admitted behind it. This effect is produced in a regular cycle by the successive opening of three valves, one at each stroke, and these valves are rotated in regular order and thus opened and closed by a ratchet-and-pawl mechanism similar to that for the conveyor screws, and operated by the small reciprocating engine. (See Fig. 2.)

The front of the plunger or ram is wedge-shaped, resembling a locomotive pilot, and when driven rapidly into the small heap of coal on the stoking plate, which has been previously placed there by the action of the conveyor screws, the little heap is thrown into the fire box over an upward sloping deflector. The force of the blow, the shape of the

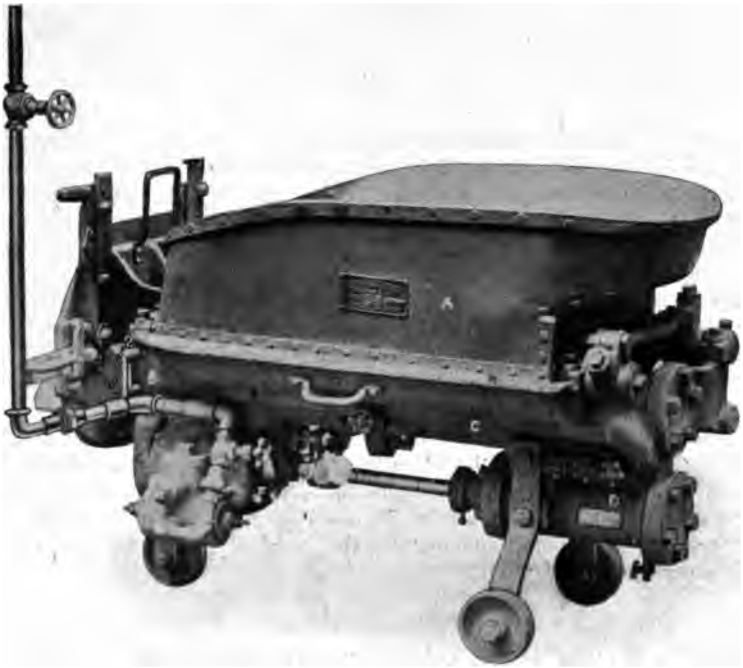


FIG. 1.— Victor Stoker.

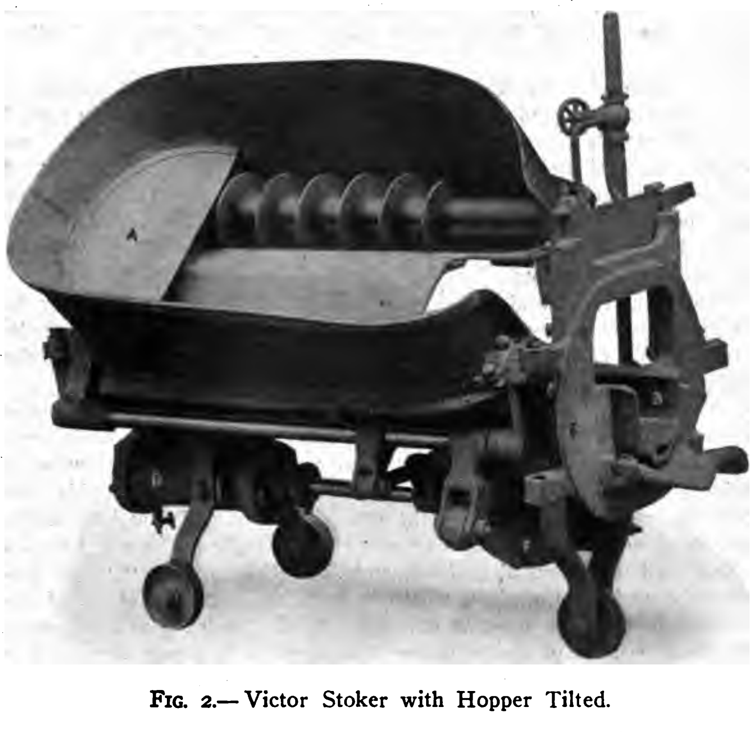


FIG. 2.— Victor Stoker with Hopper Tilted.

ram and the angle of the deflector plate all conspire to produce a spreading and shower-like distribution of the coal over the front area of the grates. The second and less violent stroke of the ram causes a similar distribution of coal over the middle area of the grates, and the third and slowest stroke showers the coal upon the rear area of the grates.

The rapid, medium and slow strokes of the plunger follow each other in regular sequence and thus the coal shower falls if we may so say, upon the background, middle distance and foreground of the fire box. The return of the plunger and piston being in each case produced by live steam pressure, the exhaust from the reciprocating and plunger engines enter the fire box over the deflector plate.

As the plunger is drawn back there is for a moment a rush of air into the fire box through the space left by the receding plunger, but this space is at once filled by coal, urged forward by the action of the conveyor screws. With this stroke the work of the fireman is to shovel the coal into the hopper and regulate the speed of the whole mechanism as circumstances may require.

THE CROSBY STOKER.

In the working of this mechanical stoker on locomotives there are practically three operations. They are the transfer of coal from the tender to the fire door, the application of the force requisite to throw the coal into the fire box, and the operation which consists of properly distributing it.

To accomplish the first operation the mechanism is so arranged as to be easily and conveniently started and stopped, and it is able to furnish a variable supply of coal. The second step is to impart sufficient force to carry the coal into the fire box, varying only in the quantity handled, the variations being arranged for in the conveyor. The last step is constant under ordinary conditions and is controllable for varying conditions. It is automatic for normal conditions and manually controllable for special requirements.

The transfer of coal from tender to fire door is accomplished by the use of a screw conveyor, extending from the coal space in the tender to the fire door, and running in a sheet-metal trough having a circular bottom and flaring sides. (See Fig. 3.)

The trough lies upon the bottom of the coal space from the rear end to a point just in front of the coal grate. At this point both screw conveyor and trough are so jointed as to provide for the motion of engine and tender due to unevenness of track, and on curves this joint allows the remaining portion of the screw conveyor and trough to incline upward to fire door, and also to allow the trough and screw conveyor to be raised to a vertical position, and stand back against the coal gate out of the way when not in use. When in operation the upper end of this part of the conveyor rests in a pivoted saddle upon the stoker proper. The lower section of the conveyor is covered with plates about a foot

long, from its rear end to within a few inches of the coal gate, when the tender is full of coal, and as the coal supply diminishes the plates are removed one by one.

The conveyor handles lumps of coal up to 10 or 12 inches, and will bring them to where the fireman can reach them. When large pieces of coal come to the joint, or as they pass up the incline they must be broken to about 4-inch lumps. This is accomplished by the use of an ordinary machinist's hammer, and the fireman stands without having to stoop while he breaks the coal.

Hanging under this upper or inclined section of the conveyor is a case containing a cone gear by which any one of several speeds may be imparted to the screw; or, it may be stopped or started. The complete control of the screw is secured by a lever placed within easy reach of the operator.

The throwing of the coal on the fire is accomplished by rapidly revolving steel blades placed within a small receiving hopper, which is carried upon a "head" similar to that used on a wood planer. The conveyor discharges coal at the required rate into the small receiving hopper, whence the blades gather it, and discharge it forcibly through a round nozzle in the door. Each of these blades discharges one-half of the receiving hopper, as they are off-set for that purpose, and are run at a constant speed when in operation.

The distribution of the coal is done by moving the nozzle as the coal emerges from it, thus distributing the coal over the fire box, showerlike from place to place, until the entire grate is covered, and constantly repeating the operation, each cycle requiring about thirty seconds.

Starting at the front left corner of the fire box, the coal is deposited in what may be called a "strip," about one-third of the width of the fire box, down the left side, including the back corner. The nozzle (see Fig. 4) then, with a quick movement, shifts and delivers coal over one-third of the width of the box, up to the flue sheet. This covers the middle third, starting from under the door. It then moves so that the coal may be delivered to the front right corner and down the right side, including the back corner. Then it quickly comes back for delivery to the front left corner, and again repeats the cycle.

A specially designed door replaces the regular fire door, and to this door is bolted a casting which is called the "main frame." It is essentially a two-chamber casting, one chamber of which is covered steam tight by a head. In this steam-tight chamber a steam turbine disk is mounted and upon which four small steam jets impinge. The other chamber contains the rotary discharger before mentioned. A shaft runs through both these chambers and carries the turbine wheel and the discharger, thus making a simple, direct connection, with only a thin partition between.

On the right, or turbine end, the shaft projects beyond the journal which carries it, and has a fly-ball governor and mechanism mounted

FIG. 6.— Crosby Stoker. The deflector removed.

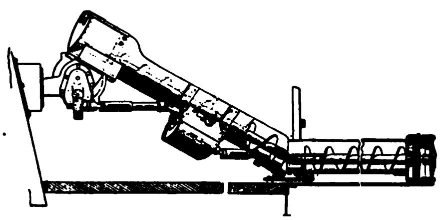


FIG. 7.— Outline of the Crosby Stoker and Conveyor.

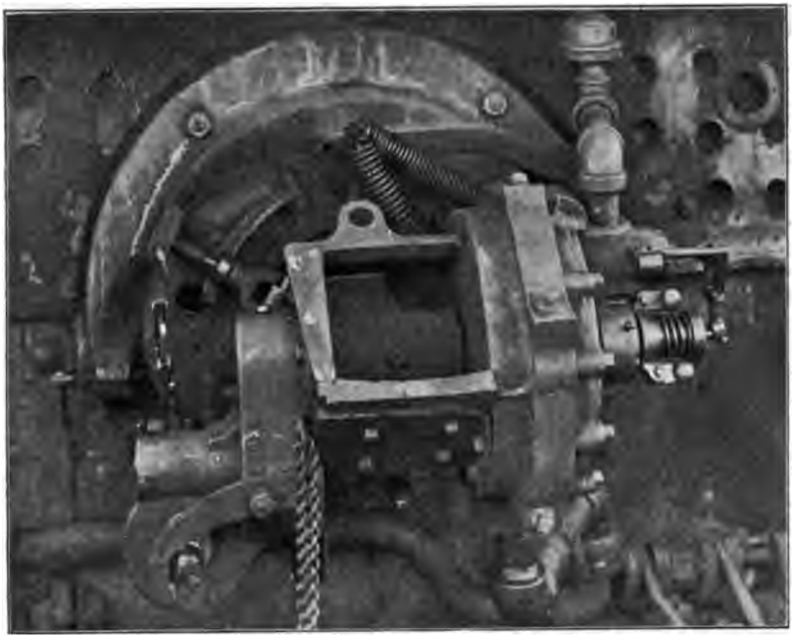


FIG. 4.— Crosby Stoker. Discharging Hopper.

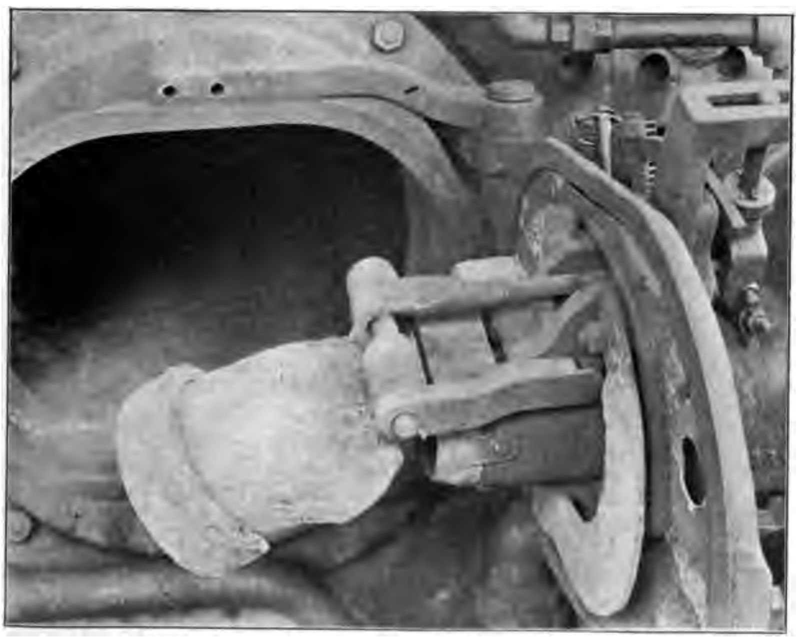


FIG. 5.— Crosby Stoker. The deflector attached.

FIG. 6.— Crosby Stoker. The deflector removed.

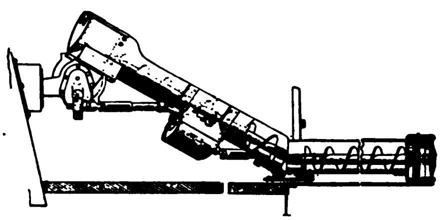


FIG. 7.— Outline of the Crosby Stoker and Conveyor.

THE STROUSE STOKER.

This stoker is of the plunger type, and although it was not evolved from what was formerly known as the Day-Kincade stoker, its general appearance is somewhat similar. It consists of a detachable frame mounted on wheels for easy handling. This frame carries a detachable hopper, a reciprocating plunger which distributes the coal and a horizontal steam cylinder with valves, valve motion, throttle lever, etc. There is a special fire door hinged at the top which opens inwardly and is operated automatically. A simple conveyor (not shown in the illustration) takes coal from the bottom of the tender and delivers it to the hopper.

The delivery and distribution of coal is effected by the action of a steam-driven plunger moving horizontally and mounted in guides. This plunger is fitted with a specially shaped steel nose as shown on photograph (see Fig. 8) taken from above at an angle of 45 degrees. Coal from the hopper feeds down into the pockets and upon the plunger nose platform in the fire-box doorway. The forward movement of the plunger scatters the coal forward and to the sides so that the forward part and front corners of the grates are properly covered. The body of the plunger when pushed forward cuts off the coal feeding from the hopper until the nose returns to its farthest back position to receive the next charge. Two pockets are provided, one on either side of the rear portion of the nose, and these carry a part of the coal into the fire box on the forward stroke of the plunger, and on its backward stroke these pockets discharge this coal onto the back corners and rear part of the grates.

The specially designed fire door (see Fig. 9) is hinged at the top and is opened and closed automatically by the operation of the stoker throttle mechanism. The whole apparatus with the exception of this door is secured to the fire-door ring by two slotted lugs and keys, and by suspension turn-buckle rods which hook into eyes on the boiler head. (See Fig. 10.) The stoker is thus easily detachable and can be quickly removed for hand firing in case of breakage. The hopper is so arranged that it can be used to fire alternate sides of the fire box, if desired. (See Fig. 11.)

The operation of the stoker by the fireman consists in regulating the speed of the conveyor mechanism and governing the length and intensity of the plunger stroke by the stoker throttle lever. The movement of the plunger is not automatically reduced to a cycle as with other forms of mechanical stokers, as the design and action of the plunger nose makes this unnecessary. The plunger stroke can be shortened or lengthened at will by the fireman, who can also vary the speed with which it moves. After having set it to work, the plunger movement remains constant until altered by the fireman. Heavy consolidation locomotives (see Fig. 12) on the Iowa Central are being successfully fired by this stoker.

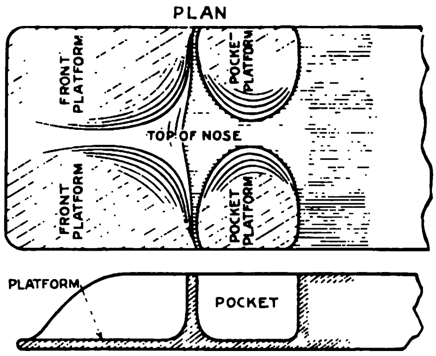


FIG. 8.— Strouse Stoker. Nose of Plunger.

FIG. 9.— Strouse Automatic Stoker. Side and End View.

FIG. 10.— Strouse Stoker. Plunger and Hopper photographed from above at an angle of 45 degrees.

FIG. 11.— End View of Strouse Stoker in Cab.

FIG. 12.— Strouse Stoker in Position.

THE HAYDEN STOKER.

The combined delivery and feeding mechanism used in this design of stoker, and by which coal is taken from the fuel space in the tender and delivered in the fire box, may be considered to be, as it actually is, two distinct pieces of apparatus. The function of the tender equipment is to convey coal to a hopper on the back boiler head, and the engine equipment consists of the appliance by which the coal in the hopper is introduced into the fire box and spread upon the fire. The operation of the stoker, as a whole, may be rendered continuous, or either or both parts of the mechanism may be stopped at will. Hand firing may be resorted to without alteration in the stoker mechanism, as it is practically out of the way of the fireman and engineer all the time.

Tracing the coal from tender to fire box, there is first the receiving grate. This is a heavy casting placed in the floor of the tender close in front of the coal gates. The casting has a series of openings 4 by 3⅜ inches, separated by narrow bridges, and through these openings the coal drops into a conveyor trough, immediately under the receiving grate. In this trough, which extends across the fuel space from water leg to water leg of the tank, are a series of buckets (see Fig. 13) carried on a pair of endless chains. The conveyor system consists of the bottom trough just referred to, at each end of which are two upright hollow tubes of oblong section, with an overhead tube, corresponding to the conveyor trough in the floor of the tender. The conveyor buckets move along the trough toward the right, up the hollow tube at that end, then back along the overhead horizontal tube, and down the left-hand hollow tube of the system. The conveyor buckets therefore travel in a rectangle, and elevate coal to a height of about six feet above the receiving grate. When the coal, moved along by the buckets, comes to the center of the overhead tube, it is discharged into a worm conveyor at the same level, which is placed fore and aft, and by means of the worm the coal slowly travels forward toward the engine, and on reaching the end of the worm conveyor trough it drops into the hopper which is carried on the back head of the boiler.

The overhead worm conveyor trough is carried on angle-iron supports, reaching, in arch form, from the top of the water legs of the tank, and additional support is afforded by attachment to the overhead conveyor tube. There is no connection between the tender equipment and that on the engine, so that by uncoupling the small steam pipes and other regular connections between engine and tender, the tender may be readily disconnected from the engine. The worm conveyor trough passes in below the overhanging roof of the cab, and is above and free from the hopper, so that inequalities of motion of engine and tender do not disturb the constant delivery of coal from the tender to the engine while the conveyor mechanism is at work.

The motion of the buckets and that of the worm in the longitudinal overhead conveyor is produced by the operation of a small twin engine

with cylinders 5 by 4 inches, with ¾ cut-off; the piston rods are fitted with Scotch yokes, which secure the rotation of the gear and sprocket wheels necessary to drive the mechanism. The engine is bolted to the right upright conveyor tube, and steam and exhaust pipes are carried through the floor of the tender and connect with pipes on the engine by means of Moran flexible joints. The steam driving the engine is taken from the outside at the top of the dome, and the exhaust connects with the blower pipe, and waste steam is discharged up the stack in a manner similar to that of the air pump. The carrying of coal from the tender to the hopper on the boiler head is performed by this small engine (see Fig. 14), and the speed of the conveyor mechanism and the speed of delivery may be regulated according to work the engine is doing at any time. Shutting off the steam supply to the small engine stops the delivery of coal.

The conveyors and small engine thus perform what is probably the greater part of the physical work of the fireman, and as such, the tender equipment might be called a mechanical coal heaver, while the task of distributing coal to the fire is performed by the engine equipment, and this latter constitutes the mechanical stoker proper.

The engine equipment consists of a hopper with a feed tube at the bottom by means of which coal passes through the fire door. There is also a set of steam nozzles and a small engine for operating an intermittent steam blast for distributing the coal over the fire. In order to describe this arrangement more minutely, it may be said that the hopper is bolted to the back head of the boiler above the fire door and has an opening of 18 by 34 inches at the top. The hopper is 25⅝ inches deep and has an opening 10½ by 6½ inches at the bottom. This opening is controlled by a slide operated by hand, and the amount of coal which passes out of the hopper is thus regulated at will. The hopper when full contains about 175 pounds of fine coal, which is the kind for which the stoker is designed.

Immediately below the hopper is the fire door, modified to suit conditions. The door contains a slightly tapering coal passage or chute, set at an angle of about 45 degrees. The function of this passage, which at its lower end is 6 by 12 inches, is to permit coal from the hopper, on the back boiler head, to be delivered to the inside of the fire box. The door is not connected with the hopper in any way, and when the slide at the base of the hopper is closed the fire door can be opened or closed by hand quite readily, as it is not a fixed part of the mechanical stoker. The coal, after it passes through this tapering chute in the door, is delivered on the door flange above the water space and on a flat table 5 inches wide by 24 inches long, which is bolted to the inside back sheet of the fire box. The fine coal thus delivered remains heaped on the table and up to the mouth of the tapering chute in the door. The size of this loose heap may be altered from time to time by the adjustment of the movable plate on the outside and upper part of the tapering chute.

Thus far the coal has been traced from the tender to the inside of the fire box. The latter part of this journey, that from hopper to what may be called the operating table, has been accomplished by the action of gravity; the final distribution of coal over the grate is accomplished by means of an intermittent steam blast, which is driven out flat over the table from five radially directed nozzles. The blast undermines and blows away the heap of coal on the table, and in the interval, before the succeeding blast of steam issues forth, the coal quickly feeds down on the table and makes a heap as before.

The mechanism (see Fig. 15) by which the intermittent blast for automatic firing is produced, consists of a smaller size of twin engine than that used on the tender, but similar in design. This engine has cylinders 1½ by 1½ inches, and the rotation of a small shaft which it accomplishes, turns a small gear wheel placed in an upright position which carries on its face a striking pin with a beveled end.

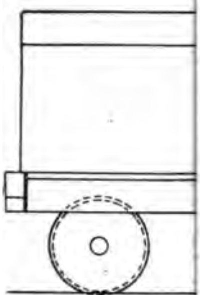
The striking pin is attached to the revolving gear wheel and is adjustable in a guideway. This striking pin when revolving strikes the beveled end of a bell crank lever and rocks it on its fulcrum at its center. This bell crank lever, when rocked, lifts a small auxiliary valve that is seated in the top cap of the blast valve. This auxiliary valve has a stem on it that extends downward through the piston valve, but the piston valve works freely on this stem and is not attached to it. The idea of extending this stem into the piston valve is to keep the steam pressure off the bottom of the auxiliary valve so that the auxiliary valve is practically a balanced valve when open.

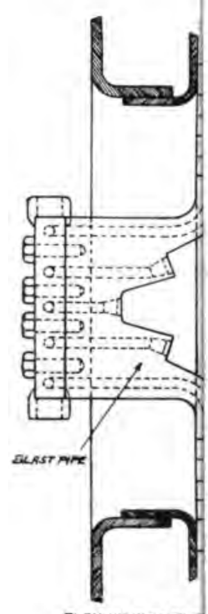
When the auxiliary valve is lifted it opens a by-pass port leading from the main steam supply to top of piston valve, thus equalizing pressure on top head of piston, allowing it to move downward and opening the passage to blast nozzles. The interior cavity of this piston valve is, when in use, always filled with steam direct from the boiler. The upper end of this piston valve has a greater area than its lower end, and, as the valve is vertical, it is normally held by steam pressure at the upper extremity of its stroke. In this position the valve is shut, for though the internal cavity is constantly full of live steam it can not escape. The opening of this valve takes place only while the bevel faces of the striking pin and lever are in contact, and as soon as the striking pin on the rotating wheel has passed beyond the lever, the internal pressure of the piston valve and the action of the coil spring at the end of the lever promptly carry the piston valve up, and so shuts off the flow of steam to the nozzles.

The travel of the piston valve, and the consequent width of opening by which steam enters the blast pipe, is determined by the adjustment of the striking pin on the small rotating wheel, and this regulates the volume of steam which gets into the blast pipe. The frequency with which the steam blasts are delivered depends upon the speed at which the small engine is run, and the pressure of the steam depends upon the

FIG. 15.— Hayden Stoker. Fire Door Closed, Erie R. R.

FIG. 16.— Tender Conveyor; Driving Engine, Grating and Trough. Hayden Stoker, Erie R. R.





PLAN VIEW OF BLA

Mr. J. F. Walsh (C. & O. Ry.): Mr. President and Gentlemen, the description of the various stokers is contained in the report. It is entirely unnecessary for me to read it. The committee, however, begs to recommend its continuance, with the idea that it may follow up from month to month the progress that is made in the matter of mechanical stoking. Up to the present moment the committee has nothing much more definite to advise concerning the subject than has just been read from the preface.

The President: This subject is now open for discussion, gentlemen.

Mr. T. H. Curtis (L. & N. R. R.): Mr. President, I have been keeping a very close watch on mechanical stokers, hoping that some day we will be able to get a steam stoker that will handle the coal. Up to the present time I have not seen a stoker that seems to me to fill the conditions, and I have very little to say on the subject at this time. I would like to hear from some of those who have had experience with stokers, and have them state what they are doing with them in this month of June.

Mr. G. W. Wildin (N. Y. N. H. & H. R. R.): Before I left the Erie Railroad they were starting to experiment with a stoker known as the Black, which was gotten up by a fireman by that name on that road. I do not see the Black stoker mentioned in this report. As there are several representatives of the Erie Railroad here, I would be glad to hear from them as to how the Black stoker performed.

Mr. John Tonge (M. & St. L. R. R.): Mr. President, I would like very much to hear something about the stoker if there is any one here who knows about it. I do not know anything at all about it, but I want to find out. It is my opinion that so far as the stoker goes we have to get down to a uniform condition of preparing the coal, and that is going to be quite difficult out in the West; but not so bad here in the East. The next thing to accomplish is to get a stoker that will be satisfactory — to get one that will be placed on the tank, one of those feed machines on which you can dump your coal. You

must have that kind of device before you have a satisfactory stoker. I would like to hear from some of the stoker men.

MR. WALSH: Mr. President, it is pretty well known that the earliest and first experiments with locomotive stokers were made upon the Chesapeake & Ohio Railway. The original locomotive stoker was invented by one of our engineers, Mr. J. W. Kincaid. The original stoker was worked by hand. A little later on Mr. Kincaid arranged to have the stoker operated by steam. The valve motion, however, on that stoker proved to be delicate and troublesome. He improved that later on and made quite a substantial mechanical arrangement of it. We own several of these stokers at the present time. We do not operate any of them. In order that the reason for that may be understood I will explain that when the stoker was first invented our locomotives were all long fire-box locomotives. Our heaviest locomotive was 100 tons approximately with 22 by 28-inch cylinders. We found it next to impossible to haul the full tonnage over a long run with those engines, and make a successful trip with the full tonnage with one man firing the engine. Those engines hauled over our River division about 4,000 tons. The Kincaid stoker, while crude at that time, did good work on those engines. We also used it to some extent on our heavy long fire-box passenger engines, where it also did good work. But with the introduction of the wide fire-box engine and their installation on those long and heavy divisions, and the transfer of the long fire-box engine to short work, so far as we are concerned, and speaking as an individual — not as a member of the committee on stokers — the necessity for the stoker on our road disappeared, because our firemen can conveniently fire the wide fire-box 100-ton 22 by 28-inch consolidation engine with 4,000 tons of freight over a 120-mile division. So that is the reason we are not now using the stokers that we own; and so far as my judgment goes in the matter, and as applied to the Chesapeake & Ohio Railway, we do not think the wide fire-box engines need a locomotive stoker.

MR. WILDIN: Mr. Walsh seems to feel that there is only one essential feature for a stoker, and that is to keep up steam. I would like to ask if he has discovered no economy in the stoker; that so long as you can keep up steam by hand, it is more prefer-

able to do it that way than to use the stoker. Is it not a fact that if you use the stoker you have less harmful influences on the flues from cold air, etc.?

MR. WALSH: Well, that was proved out, yes. We could operate our flues longer without repairing them, without rolling them. With regard to economy in coal concerning which Mr. Wildin has asked, we showed a slight economy in that; but we did not consider that either of those things were of sufficient importance to undertake the installation of stokers in a general way.

MR. WILDIN: You consider, then, that the advantages you gain would be more than balanced by the disadvantages of keeping up your stoker repairs?

MR. WALSH: Exactly. It was found very inconvenient to take care of the stokers at terminals. That was one point. As a general proposition they were unpopular with the firemen. Although they relieved them from the furnace heat and all that, they were still unpopular. There appeared to be a wrong idea concerning what was proposed to be accomplished by the stoker, and, all things considered, with the transfer of the long fire-box engines, as I remarked a few moments ago, to the short runs, we did not think there were advantages enough in the stoker to perpetuate it.

MR. L. R. POMEROY: Mr. President, I would like to ask a question,— if a stoker operated on a road in a section with the coal averaging approximately 14,000 B. T. U.'s, is there any assurance that such a stoker would be as valuable in other regions where the coal will average, say, 12,000 B. T. U.'s; or, in other words, would the action of a stoker be as good, say, with Iowa and Illinois as with Pocahontas coal?

MR. C. A. SELEY (C. R. I. & P. Ry.): I think the stoker proposition is one of the most difficult things to work out, for the reason that its operation can not be entirely mapped out by experiments with the apparatus except in service. I was impressed, at former exhibits of stokers, to see how admirably the coal was distributed over an area of considerable extent by the throwing of the coal by the machine and apparently filling

the fire box perfectly over its entire surface. As a matter of fact, however, we know that in operation the coal is not consumed in that way. The coal is not burned evenly over the entire grate, and the intelligence of the fireman is necessary in order to distribute the coal to those portions of the grate where the combustion is most intense. A former speaker alluded to the damage from cold air entering the flues. I am of the opinion that unless a stoker is very efficient in distributing the coal over the entire grate that the flues will be damaged more by air through holes in the fire, than from air entering the door.

MR. GAINES: There is on the market for stationary purposes and heating furnaces underfeed stokers, and they claim a good many advantages for them both in the way of doing away with the handling of fuel, but also in the more perfect combustion, due to the gases being distilled in the bed and then passing up through the incandescent fuel. I believe at least one of these companies is experimenting with an apparatus of this sort for locomotives, and I think it would be a good thing if our committee would look into it; and if it is not out of order, I would like to make a motion that the present committee be made a standing committee on stokers, at least until something is definitely developed, and that they look into these two forms of stoker.

MR. WALSH: As that motion was not seconded, I would advise the gentleman that one of the prominent roads in the country is now experimenting with an underfeed stoker, and that same railroad is experimenting also with a door-feed stoker; the object being, more than anything else, to eliminate smoke at the terminals through which that railroad passes. But, as there has been nothing of a definite nature brought out concerning either one of those stokers, it was thought best not to touch at all upon them. Replying to Mr. Seley, I would say that we had absolutely no difficulty whatever in distributing the coal with the Day-Kincaid stoker just as well as it could be done by hand.

THE PRESIDENT: Gentlemen, it seems a little surprising that stokers should be unpopular with the firemen; however, not more surprising, I presume, than that injectors, sight-feed lubricators and all of the modern improvements that have been

applied to locomotives at different times, proved unpopular at the commencement. The engineers and everybody else condemned them at one time, and they had to grow in favor by evolution. I presume the stokers will also become familiar and popular in the course of time.

MR. E. W. PRATT (C. & N.-W. Ry.): I will second Mr. Gaines' motion that this committee be continued in order to report further on the automatic stoker, and if there is any one who has devices of that kind they should present them to the committee for experimentation.

THE PRESIDENT: There is a motion before the house that we are holding for action later on. It was seconded and we are just waiting for the proper time to vote on it.

Mr. Bentley, you are using automatic stokers, I understand.

MR. BENTLEY: We have been experimenting with automatic stokers for about two years, but we have comparatively small engines on our road and have so far had very little difficulty in getting all the firemen we require; it has, therefore, not been necessary for us to go into the matter very extensively, and we are holding back until we find out what other people are doing who have larger engines. We have tried the Strauss and Crosby stokers. The latter machine was invented and brought out on our road, and, like everything else of a mechanical nature, it is subject to failure occasionally. We have had several in use about eighteen months, and they do the work in a fairly satisfactory manner. One objection we had to it, was that when we were working the locomotive light, the stoker had to be taken out and hand firing resorted to. That matter has been largely overcome, and the stoker where last used was doing fair work.

MR. C. E. FULLER (Union Pacific R. R.): I understand that the Erie Railroad has made a very extensive test of the stoker, and feel that this subject is one that should be fully and freely discussed by the members of this Association who are in a position to do so. I would like to have Mr. Rumney tell us what results he has obtained from the use of the stoker.

MR. T. RUMNEY (Erie R. R.): We furnished the Automatic Stoker Committee with all the information we had in regard to

stokers and gave them a series of tests which we had made, covering eighteen trips, but I do not see any mention made in the report, possibly because they did not think it of sufficient importance.

The Hayden automatic stoker is the kind that we use, and it certainly throws the coal satisfactorily, but it has not shown any economy — just the reverse. It shows an increase in consumption of coal on the east and west bound trips of 15.7 per cent, but inasmuch as there was a new fireman on practically every trip who could not be conversant with the operation of the stoker, but who were first-class firemen, a reduction in economy was not to be expected.

We are continuing the tests of the stoker and are constructing five more, and have also arranged so that there will be no hand feeding necessary. This is being obtained by changes in the construction of the tender so that it will be self-feeding to the hopper, allowing the fireman to devote his whole time to the operation of the stoker.

The class of coal we have arranged to use is everything that passes through a 3-inch screen. We expect to obtain better results than in the past.

The division upon which the stoker operates is 140 miles long, with heavy tonnage, and it frequently occurs that they consume from eighteen to twenty tons of coal on the trip.

In answer to Mr. Pomeroy, as to what results have been obtained with ordinary coal, would reply that we have used coal with 10,500 B. T. U.'s and got satisfactory results, but the coal we propose to use will run between 13,000 and 14,000 B. T. U.'s.

I have some figures showing the fuel used per ton-mile per hour, which was, with the stoker .6494, and without the stoker .5609, or an increase in consumption with the stoker of 15.7 per cent.

MR. W. C. SQUIRE: I would like to ask Mr. Rumney as to the personal equation of the firemen. Is it not possible to reduce the 15 per cent so that it will meet the personal equation of the fireman himself? There might have been a difference of 25 to 30 per cent, which is not unusual.

THE PRESIDENT: Mr. Wickhorst, I understand, has had experience in this line.

MR. M. H. WICKHORST (C. B. & Q. R. R.): My knowledge of stokers is somewhat out of date, as it is several years since I have made any tests of them. We tried a Day-Kincaid stoker in which the coal was fed by means of a steam-driven ram, and we also tried a Luckey stoker in which the coal was fed into the fire box by means of a jet of steam. Both of these stokers had deflector plates to spread the coal. They were, however, only partially successful. I have had an idea that possibly a chain grate could be devised, but the difficulties now seem to be insurmountable both as regards adaptation to a locomotive and as regards rates of combustion per square foot. Then again, analyses of smoke gases have shown that by skilful hand firing combustion is almost perfect, and this would argue in favor of a method of mechanical stoking which simulates hand firing. Our people have been experimenting with a Barnum underfeed stoker, but as yet this is simply in the experimental state.

PROFESSOR GOSS: Mr. Chairman, and Gentlemen: My experience with the locomotive stoker, like that of Mr. Wickhorst, is rather out of date. A few years ago, however, I ran a large number of tests upon a locomotive when fired by a Day-Kincaid stoker. At that time, I gave some attention to the whole problem of stoker design. I soon became convinced that we expect a great deal of the stoker designer when we require him to produce an apparatus which can be moved up to the fire door of a normal locomotive as designed for hand firing and expect it to do the work of a formal stoker installation. It is altogether likely that when the satisfactory stoker comes, it may bring with it a demand for changes in the design of the boiler. For example, the success of the Day-Kincaid stoker, and others of that type, would have been much more readily assured if, in applying it to the narrow fire-box boilers there had been a supplemental fire door, the whole arrangement being such that the stoker could have its own fire door, located a little below the normal door lever. A deck could then be laid above the stoker with a grating in it through which coal could be dropped. By carrying the coal high on the tender, it would require little

handling; it would simply need to be drawn forward, broken when necessary and dropped through to the hopper of the stoker. Above the deck there should be the usual door for hand firing. Through this door, the fireman would at all times have a chance to reach his fire without the necessity of backing away the stoker or of interfering with it in any way. I speak of this merely as an illustration of the sort of modification in boiler design which we should be prepared to accept if we desire to make progress in the adoption of the automatic stoker. As has been said, the mechanical details of the Day-Kincaid stoker were not entirely satisfactory, but it should not be forgotten that in a narrow fire box it spread the coal perfectly and that its capacity exceeded the requirements of the largest locomotive of the present day. If the locomotive designer could have met the stoker designer half way, I think that much more would have been accomplished by its use.

The question of economy from the use of a stoker is entirely one of skill and attention in operation. The stoker puts the coal into the fire box with very great ease, and any lack of attention on the part of the fireman will lead to over-firing and fuel waste. With a stoker, however, it is probable that given results could be accomplished by use of a lower grade of fuel than could be had with hand firing.

As to the type of stoker which will ultimately come into use on our locomotives, predictions are always dangerous, but it seems to me that any type of stokers such as the chain grate, which represent a long continued process, will, on a locomotive, be confronted with a great many difficulties. The conditions under which the locomotive performs its service make it absolutely essential that a stoker be capable of responding to rapidly varying demands upon the fire, and a stoker of the chain-grate type will not so respond. It is here that the automatic shoveler of the Day-Kincaid type shows its worth. By the use of such a stoker, a light fire may be built up more rapidly and with greater certainty than can be done by hand firing.

DR. ANGUS SINCLAIR: Mr. President and gentlemen of the Association: I have paid considerable attention to this subject in connection with combustion in locomotive fire boxes. Away

back when they were experimenting with various kinds of fire boxes for burning coal an invention was gotten out by a New York railroad man for burning coal smokelessly on a movable grate. There was some difficulty experienced with the action of the grate in the case of the first inventor, but others took the matter up to some extent, and experimented with the movable grate, as an automatic stoker. It was not successfully done, however, and, as far as I can make out, the influences against it were strong enough to have it thrown aside. The firemen have no particular use for it, and with the small fire boxes in use at that time, there was really no urgent necessity for an automatic stoker.

The revival of the sentiment in favor of automatic stokers came with the very long fire boxes that were almost impracticable to fire with the scoop, and with that kind of fire box, the automatic stoker was a success. Had these long fire boxes been perpetuated as the freight fire box for the locomotives of America, you would have automatic stokers in full blast to-day. With that kind of fire box it was entirely a success, and much more successful than the hand firing.

When you went to the wide fire box Mr. Walsh speaks about, the fireman became superior to the automatic stoker, and as long as that condition exists — while there may be a great deal of effort to make successful stokers — I do not believe there will be any inclination among railroad companies to patronize them sufficiently to pay for the work done in getting out the stokers.

The condition of the art at present, as far as I understand it, is, that the mechanical stoker came up to be suitable for a certain fire box, that fire box only, and then another form of fire box came in and the mechanical stoker is not well adapted to the new form of fire box, but the fireman's work is well adapted to the new form of fire box, so the consequence is that there is not an active demand any more for an automatic stoker.

Mr. Gaines: I will take exception to Mr. Sinclair in the statement he makes that there is no demand for an automatic stoker. I believe there is a demand in this way — that the limit of a fireman has been reached on some of our big engines, even with wide fire boxes, in hot weather. On a 180-mile division,

with a wide fire box, one fireman is all in in the course of a trip over that division firing one of these engines. I believe there is a field for the automatic stoker, and I am simply waiting for the right one to develop. I think we have lost sight of this fact, as some of us who have spoken here have done, that is, that there are some engines that can not be fired to full capacity by hand firing. If we had an automatic stoker in such cases we could work the engine to its maximum power and we could go over the road more quickly, and pull more tonnage.

MR. J. F. DEVOY (C. M. & St. P. Ry.): I am rather inclined to agree with Mr. Sinclair. I do not say there is not, or will not be, a demand for a mechanical stoker, but it appears to me and has appeared to me, for the past five or six years, that if boiler designers would give more attention to the construction of a fire box that results could be obtained which would meet all requirements. It is a fact, in my mind, that the increased capacity of cars, trains, and their movements can be met by a fire box having a grate surface not exceeding 55 square feet. I think it is a positive fact, and I believe my opinion is shared by a great many men, that it is entirely possible for a man to fire that size of fire box, when an engine is developing its maximum capacity of, say, 2,000 horse-power. You know on the Milwaukee road we were very much criticized, and found fault with, for insisting on the narrow fire box; but it was a positive fact that we obtained as good and economical results with a narrow fire box, as with a wide fire box. However, we believed that there was a point between the narrow and the wide fire box in which both conditions could be met. We believed that the depth of the fire box had more to do than any other thing, and the superintendent of motive power and myself, a year ago, argued two days with the representatives of the American Locomotive Company for two additional inches in depth of fire box, and we argued long enough to get it. Three years ago we were found fault with when we said that a depth of 32 inches from the lower side of the throat to the bottom of the mud ring could be obtained. We have done that and more too, and it has had more to do with the proper combustion than anything I know of. We have now gone from the narrow fire box to a

width of 60 inches, and we believe that a width of 60 inches is a proper thing for burning bituminous coal, and as I said in the beginning, while it may be going back, in the opinion of some of our members, I am inclined to agree with Mr. Sinclair's remarks that the time is not here when an automatic stoker can successfully compete with a properly designed, properly hand-fired boiler.

MR. J. F. DEEMS (N. Y. C. Lines): I want to emphasize what Mr. Gaines has said and disagree radically from the remarks of Mr. Sinclair and Mr. DeVoy. I am not prepared to say that the stoker is here — in fact I think it is not — but I certainly feel that if there is a demand, an urgent demand, for any one thing on the railroads of this country it is a successful mechanical stoker.

We heard it stated on the floor of the convention the other day that the Mallet compound would probably be looked upon favorably for hauling freight trains in the near future, and with that confronting us, or even without that, taking the heavy engines we have in service to-day, I do not believe there is anything, at least I can not think of any more important development to-day, that will mean as much to the railroads of the country than a successful mechanical stoker for locomotives.

This subject is surrounded with a great many questions which hardly seem necessary to be brought up at this time, but I want to strongly emphasize what Mr. Gaines has said, and I believe there is nothing at the present time for which there is such a crying demand as for a mechanical stoker.

PROF. H. WADE HIBBARD (Cornell University): Occasionally a man who is out of active railroad service may say a word or two that a man in active railway service may think inadvisable to be said.

The thing that appeals to me in the coming of the mechanical stoker is the human side of it, and going a step further, I think with Mr. Gaines, heartily approving of every word that he said, the mechanical stoker, in making the work of the fireman less laborious, is inevitably going to make the fireman's position more attractive to the brainy young fellows from the public schools

who now do not care to become firemen, because they say it is work for a horse and not for a human being.

The conditions in firing a locomotive boiler are different from the conditions in the stationary boiler room. We require as firemen for locomotive boilers men who are suited for promotion later to be engineers, and if we expect to get the right sort of brainy, responsible fellows for engineers, then we have got to get these brainy, responsible fellows for firemen, and to my mind, that is the important thing in the coming of the mechanical stoker, that it will make the position of the fireman more acceptable to the class of men the railroads want as engineers at some later time.

MR. POMEROY: I desire to say a word following the suggestion of Mr. Gaines in connection with a certain class of 2-8-0 locomotives under test on a mountain grade division of a certain western road, it was found that by the combustion of 150 pounds of coal per square foot of grate surface, per hour, the maximum tractive force could be carried up to ten miles per hour, but owing to the inability or physical limitations of the fireman to shovel more than 7,600 pounds of coal per hour, or about 135 pounds per square foot of grate surface per hour, the maximum tractive force could not be carried beyond seven and one-half miles per hour, which leads me to the point which I desire to make, i. e., that inasmuch as in some sections of the country, particularly with low grade fuel, the speed limits at maximum tractive force of the large locomotive is limited by the ability of the firemen and not by the design of the engine *per se,* therefore any form of stoker that could handle even one-third of the required amount of fuel would prove a good investment, because, when used, it would make it possible to realize the full capacity of the so-called large locomotive. For this reason there is good argument for the stoker and we should encourage this development in every way possible.

MR. VAUGHAN: The stoker proposition has comparatively little interest for us on account of the fact that on the majority of our lines the grades are comparatively short and the weather is cool, and the fireman is consequently not very heavily taxed. We have, in common with a good many people, tried one or two

types of stokers, and the men have objected to them — I will not say objected to them so much as they preferred to handle the engine without them, but what strikes me peculiar in this discussion is that Mr. Walsh tells us he has had a stoker which has given good success, and which he has used for a couple of years. Mr. Deems and Mr. Gaines say there is a crying need for a stoker, and their attitude is that they are ready to try a stoker, as soon as a successful one has been brought out.

I would ask Mr. Deems and Mr. Gaines if they have given the stokers Mr. Walsh has made a success of, a fair and reasonable trial? It is all very well to say we have a need for a thing; I do not know what stoker Mr. Walsh has tried, but it would appear that a stoker is on the market which gives good results, and if that is so, and other people are in need of them, why not give these successful stokers, to which reference has been made, a trial and see if they will meet conditions.

I have a feeling about the stoker matter — it is almost a perennial matter with us now — that while it may have certain advantages, there are disadvantages inherent in the use of a mechanical stoker, at any rate with the present design of boiler, that must make it more or less objectionable. I do not see how a man is going to obtain an absolutely uniform firing over long divisions, and meet the same demands of firing as he can with hand firing and I do not see how a man whose fire gets into bad shape can get it into good shape as well with the mechanical stoker as he can with hand firing. Hand firing to be sure is very laborious work, but it means a good deal of brain power to do it properly. I do not believe any one will deny there is a good deal in good firing and that much of the excessive amounts of coal burned are caused by men firing heavily and carelessly, and if more attention was paid to firing — if more brain power was used in conjunction with the physical power — it would not be so laborious, and the fireman would get along better.

The proposition of Dean Goss strikes me as the most favorable in the stoker line, that is, to have an arrangement that would deliver a certain proportion of the coal, and supplement that by hand firing. If an apparatus could be designed reliable enough to give us a portion of the coal, fed automatically, and let the

fireman supplement that with hand firing, he would have a chance to employ the hand firing to the best advantage, where it is needed most, cover up bright spots, and could keep the fire in good condition for a considerable time. Such a proposition might be a good one.

We have all had experience in putting any appliance on an engine. It seems as if you could absolutely put nothing on an engine that did not give you considerable trouble to maintain it. Everything you add to an engine, no matter what it is, is so much additional trouble. Under the system of pooling engines, and the amount of maintenance that our American engines are receiving, it is certain that the addition of a stoker on an engine will lead to more roundhouse work, and occasionally to failures, and it is the failures that condemn most devices.

We find, as a rule — take, for instance, the matter of injectors — that where a device has real merit, and you get one or two pretty good men to handle such a device for a year or two, and they are successful with it, that the men very generally come to like it and approve of it. Where you find the men consistently and continually opposing a device, there is nearly always a reason for it which you have not got on to. That has been my experience in many cases. Even though you put appliances on your engines, which you think are all right, and even though you get good reports of their service from your Master Mechanics, yet if your men dislike them and object to them, you will generally find there is sufficient ground for the dislike, and I think the reason for the objection to the mechanical stoker is that it really needs a certain amount of hand firing to keep the fire in shape.

MR. S. M. VAUCLAIN (Baldwin Locomotive Works): I have very little to say about the automatic stoker. We have been interested in it ever since automatic stokers were talked about, and believe we were the first ones to become interested in the matter with Mr. Walsh on his line, and we assisted in some of the experiments which he made.

It has been very amusing, and also very instructive, to listen to some of the views which have been expressed in regard to automatic stokers by the gentlemen present. I do not think

that any of them need worry very much, judging from the particular standpoint which they took in discussing the subject. I think that if an automatic stoker can be made which will properly stoke the locomotive, that there will be no difficulty in introducing it, and it will not only be sought for by those who have charge of locomotives, but it will also be asked for by those who are to operate them.

So far as getting husky firemen for the future is concerned, inasmuch as we may have to rely on college-bred men to do our firing, I anticipate not the slightest trouble, because that seems to be a requisite in all the college men to-day, to be husky, and able to handle things of that kind. In fact, I think the young men who are coming along, and the young men whom we can see will be coming in the future, will be just as husky as the young men of the past, and in addition to that they will be more intelligent. Having this intelligence, they will, of course, be called upon to make less exertion in firing the same quantity of coal, and consequently, in the case of larger locomotives, they will be able to fire a locomotive with the same or less exertion than the young men of the past fired their smaller locomotives.

I think it is unwise to stop experimenting with automatic stokers for locomotives just as it would have been unwise to stop experimenting with automatic stokers and movable grates for stationary purposes. The problem, however, is somewhat difficult, and, in order to have an automatic stoker entirely successful, it would appear to me as though the design should contemplate conducting the coal from the tender to the fire box without physical labor. So long as physical labor must be employed to place the coal in the stoker, and look after the many peculiarities that the machine itself may have while it is operative, I think we will continue the firing of our locomotives by hand.

MR. G. R. HENDERSON: I was not here during the early part of the discussion of the paper on stokers, but heard some of the remarks that Mr. Vauclain has made, which I think is the secret of some of the troubles which have been experienced with automatic stokers in the past.

There is no question that the automatic stoker, to be successful, must handle the coal, as Mr. Vauclain suggested, from the

tender into the stoker, and I believe there are some stokers in the market which are now doing that. I think that the principal trouble with the stoker to which Mr. Walsh referred, was the management of the company organized to take care of the stoker, and to put it on the market. It has had an unfortunate experience in connection with the different parties who handled the stoker, and I think the principal trouble has been on account of the way it was handled.

As to the need of the stoker, there was a report in the last number of the *American Engineer* showing the operation of a Mallet compound on the Erie, which stated that the maximum coal consumption was 50 pounds of coal per square foot of grate per hour, an average of 5,000 pounds of coal per hour. The report showed that the locomotive went up the hill at a speed of six miles an hour. That is the greatest advantage that the stoker ever presented. As to the capacity of a fireman, whether he is a "college slugger" or a "prize fighter," we know his capacity is about 6,000 pounds of coal an hour. We know we can burn in a locomotive 200 pounds of coal per square foot of grate area per hour, and certainly 100 pounds of coal per square foot of grate area per hour is not exorbitant. This Mallet engine only burned 50 pounds of coal per square foot per hour. It is evident that the fireman could not get more into it. If the engine had been provided with some kind of mechanical stoker, which would have supplied it with all the fuel it could have consumed, it would have gone up the hill at twelve miles an hour instead of six and it would have accomplished double the work for the same time.

THE PRESIDENT: Do you care to sum up the argument, Mr. Walsh?

MR. WALSH: No, sir, we have nothing more to say. We will be glad to serve the Association and report the results as continued investigation goes along.

As I remarked this morning, earlier, there are two or three stokers being experimented with and perhaps in the course of a year or two, we can get considerable intelligent information upon these, and very interesting information, no doubt, but I do not think I have anything more to say, or that the committee has

anything more to say. I am sorry that the chairman of the committee is not here, because Mr. Garstang has had considerable experience with the Day-Kincaid stoker on his own line.

THE PRESIDENT: Gentlemen, the motion before the house is that the present Committee on Mechanical Stokers shall be continued and made a standing committee.

The motion was seconded and carried.

THE PRESIDENT: We will now take up the report of the committee on "Blanks for Reporting Work on Engines Undergoing Repairs," Mr. Theodore H. Curtis, chairman.

MR. CURTIS: This report was presented to the Association once before, and as this second report is very short, I will again read it.

REPORT OF COMMITTEE ON BLANKS FOR REPORTING WORK ON ENGINES UNDERGOING REPAIRS.

(SUPPLEMENT TO REPORT SUBMITTED AT JUNE, 1907, CONVENTION.)

To the Members:

The Committee on Blanks for Reporting Work on Engines Undergoing Repairs, which reported at the last Convention, was continued for the purpose of submitting additional reports showing the condition of locomotives in service in addition to those undergoing repairs.

We submit at end of this report, Form "Exhibit G," which we believe covers in concise form the additional information desired. This report should be made monthly by the Division Master Mechanics to the Superintendent of Motive Power.

The daily reports referred to in the discussion of this subject at the last Convention would be of service to Division Officials, but we believe that such a system can not be successfully handled by the General Officers of a large railroad and that on railroad systems owning 500 locomotives, or more, a monthly report of the conditions from the Division Officials is preferable to a daily report. We submit this report as a supplement to the original report which, for convenience, is reprinted as a part of this report.

When your committee made its original report it did not understand that a report showing Work on Engines Undergoing Repairs should include a report on Condition of Engines in Service.

Respectfully submitted,

THEO. H. CURTIS,
E. W. PRATT,
C. H. QUEREAU,
F. W. LANE,
Committee.

REPORT OF COMMITTEE ON BLANKS FOR REPORTING WORK ON ENGINES UNDERGOING REPAIRS.

(Submitted at Convention of 1907.)

To the Members:

Your committee appointed to recommend "Blanks for Reporting Work on Engines Undergoing Repairs" presumes that it was intended that this report should embrace blanks for reporting engines which are in service but need shopping, and blanks for reporting work done on engines which have undergone repairs, to be used as a permanent record. A report based on the literal reading of the subject assigned would seem of little value. We have also presumed that the report is to cover shop repairs and not running repairs.

Under the present method of making heavy or extensive repairs to engines at one or two main shops, and of making only light or running repairs at the small division shops or terminals, and of running engines out of terminals in either direction in pool service, and where Division Master Mechanics have no regular assignment of engines and, therefore, can not be held entirely responsible for the condition of engines on their respective divisions, the most important and essential feature in connection with the cost of "Repairs of Locomotives" and the results in operation is that of obtaining a correct and accurate report of the condition of engines in service, that they may be sent to the shops best equipped to do the class of repairs which they need, and that the condition of the engines on the various divisions may be kept consistent with the service required.

In order to assign engines to the shops intelligently, an accurate report of their condition and a comprehensive classification of the repairs required is necessary. Your committee does not believe that the "Classification of Locomotive Repairs" as recommended by the committee appointed on that subject, and which reported at the last convention, is best adapted for this purpose.

The operating officials in all departments are gradually adopting the use of the classification in vogue in the Motive Power Department on their respective roads, particularly with regard to engines in shop for repairs, and the classification should, therefore, be one that is free from complication and easily understood. In addition to the classification recommended by the committee at the last convention being complicated, it costs considerably more to make repairs in some cases than in others, though the classification is the same. We believe the most practical and comprehensive classification is the Unit classification, based on the estimated cost of repairs, and have, therefore, used it in connection with the blanks recommended in this report. Under the Unit system engines requiring repairs estimated to cost $100 is termed class "1" repairs; $500, class "5" repairs; $800, class "8" repairs; $1,500, class "15" repairs;

$3,000, class "30" repairs, etc. We also consider a more detailed report than the mere classification number (under any system of classification) is necessary in order to intelligently assign engines to the shops for repairs.

In order not to hold engines out of service awaiting room in the main shop, it can not be left to the discretion of division officials to forward engines to the main shop. They should be assigned to the shops by the head of the Mechanical Department, or one delegated by him to perform this duty. A record of the mileage made by each engine between shoppings and the repairs made to the engines at previous shoppings, as well as accurate reports of the condition of engines and a knowledge of the service required on each division, is essential to intelligently make shop assignments and secure the longest and best possible service at reasonable cost.

Your committee obtained from the heads of the Mechanical Departments of the principal roads forms in use for this purpose, and, after a careful analysis of the subject and the forms submitted, recommend the use of the following blanks:

1 (Exhibit A). Blank showing condition in detail of engines which will require shopping within thirty days. This report is in duplicate form and that part pertaining to the condition of the engine is made by the Division Master Mechanic where the engine is in service and forwarded to the head of the Mechanical Department. The information relative to date, place and class of repairs, and mileage made since last shopping is inserted in the Superintendent of Motive Power's office, and if the shopping is approved the engine is ordered to such shop as best adapted to do the work required and at such time as it can be relieved and space can be assigned it in the shop. The original report will, at that time, be sent to the Master Mechanic or Superintendent of shop to which the engine is assigned for repairs, and the duplicate report filed in the office of the Superintendent of Motive Power as a permanent record. The Master Mechanic making the report should be held equally responsible with the Master Mechanic making the repairs for failure to report repairs needed to essential parts, if they are not made.

2 (Exhibits B and C). Blank (Exhibit B) is a weekly report to be made by each Master Mechanic to the head of the Mechanical Department, showing "Engines Turned Out of Shop," with date taken in, date turned out, and class of repairs made; "Engines in Shop," with date taken in, date will probably be turned out, class of repairs, and, if waiting on material, the items, date and number of requisition upon which it is ordered; "Engines Out of Service, Waiting Repairs Account No Room in Shops," with date taken out of service, and class of repairs needed; "Available Track Room in Shop for More Engines," with number of additional engines that can be taken in shop.

From these reports a very concise statement (Exhibit C) can be compiled to be submitted to the heads of the Operating Department, but a

printed form is not desirable for this statement as it can (on account of the varying number of engines in shop) be made on typewriter in more concise form.

3 (Exhibit D). Blank showing in detail repairs made to the various parts of engines, dates in and out of shop, mileage since last shopping, cost of repairs (with that due to collision and accident shown separately), and other general information which is of interest as a permanent record.

4 (Exhibit E). Blank showing in detail stay-bolt test and fire-box inspection and renewal of stay bolts. This blank is supplemental to blank Exhibit D, and is an essential record which can not practically be incorporated in blank Exhibit D.

5 (Exhibit F). Blank showing continuous shop record, mileage, cost of repairs of each individual engine. This is a permanent record for use in the Superintendent of Motive Power's office and the information is obtained from reports made on blanks Exhibit D, as furnished by the various Division Master Mechanics.

All of the foregoing blanks should be made of loose leaf form, that they may be bound in suitable binders. Blanks A, D, E and F should be bound with engine numbers in consecutive order and each fiscal year in separate volumes. Blanks C and D should be bound in order of date.

Many of the railroad companies submitted numerous blanks used by them in connection with shopping and repairs to engines, but we believe that a complicated system of numerous reports is expensive and undesirable and that the foregoing blanks are sufficient to furnish a practicable and permanent record of work done on engines undergoing repairs.

THEO. H. CURTIS (Chairman),
E. W. PRATT,
C. H. QUEREAU,
F. W. LANE,
Committee.

CHICAGO, ILL., May 3, 1907.

A. B. and C. RAILROAD COMPANY.

Mr. ______________________
Supt. of Motive Power.

______________________   ______________________ Division, ______________ 190

Engine No.__________ requires the following repairs and should be shopped during the next thirty days. Estimated class of repairs needed______________________

ENGINE PARTS	WORK REQUIRED
Boiler	
Fire Box	
Flues	
Frames	
Wheel Centers	
Axles, Driving	
Cylinders	
Crank Pins	
Driving Boxes	
Tires	

REMARKS.—(State other heavy work required not shown above.)

____

____

____

____

____

*LAST SHOPPED.—Date__________190   Place__________   Class repairs

Mileage made since last shopping__________miles.

SHOPPING APPROVED:

Supt. of Motive Power.   ______________________ Master Mechanic.

Ordered to__________________Shops, Date__________________190.

____
Supt. of Motive Power

* Information regarding "last shopped" and mileage made will be inserted in Supt of Motive Power's Office.

NOTE—Original of this report will be sent to the Master Mechanic of the Shop to which the engine is assigned when the assignment is made. Duplicate report will be filed in Superintendent of Motive Power's Office.

EXHIBIT "A."

A. B. AND C. RAILROAD COMPANY

OFFICE OF MASTER MECHANIC.

REPORT OF ENGINES REPAIRED AND UNDERGOING AND WAITING REPAIRS.

Shops, week ending ____________ 190__

ENGINES TURNED OUT OF SHOPS

Engine No.	Date Taken in	Date Turned out	Class of Repairs	REMARKS

ENGINES IN SHOPS

Engine No.	Date Taken in	Date will Probably be Turned out	Class of Repairs	If Delayed Waiting Material, State Briefly what it is and Date and Number of Requisition on which Ordered

ENGINES OUT OF SERVICE, WAITING REPAIRS ACCOUNT OF NO ROOM IN SHOPS.

Engine No.	Date Taken out of Service	Class of Repairs	REMARKS

If there are facilities and space in shop available for repairs to Engines, state how many Engines could be accommodated if they could be spared from service.

____________ MASTER MECHANIC.

CLASSIFICATION OF LOCOMOTIVE REPAIRS.

$ 100.	—Cost of Repairs—Class	1
300.	— " " " — "	3
700.	— " " " — "	7
1.000.	— " " " — "	10
1.500.	— " " " — "	15

EXHIBIT "B."

A, B AND C RAILROAD COMPANY.

ENGINES TAKEN IN SHOPS WEEK ENDING APRIL 27, 1907.

Engine No.	Date Taken In.	Date Will Probably Be Turned Out.	Class of Repairs.
......Shops.			
779	April 8	May 7	15
2061	April 8	May 17	18
341	April 20	May 20	18
......Shops.			
273	April 12	April 30	10
2023	March 23	April 30	20
539	April 20	April 30	15
1111	April 26	May 3	4
719	March 23	May 4	28
547	April 24	May 4	12
137	April 20	May 4	26
166	April 20	May 7	150
400	April 1	May 8	20
2012	April 27	May 10	15
920	April 23	May 11	23
31	April 15	May 11	18
887	March 23	May 11	33
343	April 9	May 11	20
768	April 26	May 14	15
724	April 25	May 15	18
918	April 3	May 18	40
604	April 20	May 20	35
806	April 15	May 20	40
......Shops.			
608	April 2	April 30	18
1049	April 22	May 1	2
607	March 26	May 7	21
266	April 8	May 7	16
503	April 20	May 9	18
764	April 12	May 16	19
959	April 23	May 20	17
......Shops.			
1088	April 21	April 27	1
332	April 11	April 30	3
453	April 25	May 3	1
361	March 23	May 4	10
129	April 15	May 15	7

Engine No.	Date Taken In.	Date Will Probably Be Turned Out.	Class of Repairs.
......Shops.			
754	April 26	April 30	1
446	March 14	May 4	12
201	April 24	May 4	3
642	April 10	May 10	12
......Shops.			
987	March 27	April 30	20
1068	April 10	April 30	7
718	March 30	May 2	18
153	April 22	May 4	5
1014	April 21	May 8	7
1055	April 21	May 11	7
924	April 4	May 15	22
1003	April 6	May 15	25
109	April 21	May 16	13
984	April 19	May 18	20
612	April 19	May 22	20
438	April 26	May 25	22
......Rd. House.			
262	April 22	April 24	1
1162	April 22	April 25	1
416	April 21	April 26	1
133	April 26	April 29	1
......Shops.			
58	April 24	April 26	2
329	April 19	April 29	5
123	April 5	May 1	8
330	April 24	May 4	5
529	April 24	May 6	5
1	April 5	May 20	20
......Shops.			
2072	April 26	April 29	1
119	April 21	April 30	2
......Shops.			
2020	April 22	May 2	6

ENGINES TURNED OUT OF SHOPS WEEK ENDING APRIL 27, 1907.

......Shops. 41, 225, 640.
......R. H. 262, 416, 1162.
......Shops. 116, 118, 627, 774, 879, 897, 1081.
......Shops. 704, 870, 930, 1081, 1062, 1067, 2032, 1145.

......Shops. 543, 900, 2069.
......Shops. 442, 2014, 1088, 1080.
......Shops. 68, 2106.
......Shops. 606, 712, 713.
......Shops. 960

OFFICE OF SUPT. MOTIVE POWER,
........., April 29, 1907.

....
Supt. Motive Power

EXHIBIT "C."

CLASS
BUILT AT
DATE OF SERVICE

A, B AND C
RECORD OF LOCOMOTIVES

	Where Overhauled	In Shop			Out of Shop			Mileage Since Last Shopped	Labor		Cost of Material	Total Cost	Cost Due to Accident	Boiler	Fire Box	Flues	
		Day	Mo.	Year	Day	Mo.	Year		Boiler	Machinery							

EXHIBIT "F," PART 1.

RAILROAD COMPANY.
OVERHAULED.

ENGINE No.

	Flue Sheet	Stay Bolts	Frames	Wheel Centers	Driving Axles	Cylinders	Driving Boxes	Tires	Cab	Tender	Brakes	

EXHIBIT "F," PART 2.

A. B AND C RAILROAD COMPANY.

PARTMENT.

Report of work done on Locomotive No......................................

After reading the report Mr. Curtis said: In this respect, I wish to say that reporting locomotives is largely a local matter. Large roads can not use the same system that small roads can use.

In looking over the report of last year, I will say in reference to Exhibit A that this report should be made and sent to the Superintendent of Motive Power of the road so that he can look over the report and know the condition of power, and also get a detailed statement of the locomotives which have been shopped.

On Exhibit B there is a blank for the purpose of showing locomotives turned out of shops, in the shops, and awaiting repairs.

Exhibit F, part 1 and part 2, are for permanent reports of locomotives that have undergone repairs.

Exhibit E is for reporting stay bolts.

Exhibit D represents a report that is made up from several reports obtained from different railroads. There are some parts of locomotives which are not enumerated in this report. However, each railroad will have to make this form to suit the parts on its locomotives.

Exhibit G is the last exhibit, and the new part of this report is a monthly report for the different divisions. On roads having only one or two divisions, this report can be eliminated.

I believe I voice the opinion of our committee in saying that in presenting these reports, we feel that the forms given here may be a good suggestion to a road desiring to make a change, or to establish reports of this kind. However, we do not feel that these reports or forms are suitable for all classes of railroads.

The President: The report is here before you for discussion, gentlemen.

Mr. Gaines: I raised some little question last year to the report blank which refers to the daily condition of engines, and I would like to say a word more about it. I have been on a road on which we had between 1,000 and 1,100 engines. We found it absolutely necessary to know each day what proportion of the engines we could count on for service, so that if a congestion occurred on one section, and needed more engines, we

could supply these engines. Since that time I have been connected with a smaller road which has a smaller number of engines, and I find my daily report of the condition of the engines a very important document. We make a report blank similar to that of Exhibit B, and it is made up along these lines some time each afternoon, and I receive it the next morning. I know what engines have been shopped, and what engines are in the shop for light repairs, and what engines have been turned out. If the General Manager should call on me quickly to know if I can spare some engines, and send them to a point where there is a congestion I am able to size up the situation and tell him at once what can be done. I do not see how, without some report of this kind, you are going to give information to the general officers regarding the condition of the motive power when they call upon you for such information.

Mr. Curtis: In reply to Mr. Gaines, the committee feels that reporting the daily condition of locomotives is entirely a division, or local, matter. The Division Master Mechanics on the L. & N. R. R. report to their Division Superintendents each morning the number of available, or serviceable, locomotives at the terminals, and if any are at the terminals unserviceable, the probable time they will be ready for service, that the Division Superintendents may arrange for movement of trains accordingly. A telegraphic report of these conditions is made by the Division Superintendents to the Superintendent of Transportation daily, so that in event there is a shortage of engines on one division and a surplus of engines on another division, they may be transferred accordingly. We do not consider it essential or practicable for the Superintendent of Motive Power to be furnished with a daily report showing condition of all engines on the road.

Mr. Wildin: I hardly think we will ever get to a standard form for reporting matters of this kind that will be suitable for all roads. I also feel that most roads are covering practically the ground covered in this report in one way or another. The Superintendent of Motive Power or Mechanical Superintendent should be fully advised every morning as to the whereabouts and the condition of his power, and it is necessary also for the

transportation people to know. When a freight blockade comes and power is scarce, the first man jumped on is the Superintendent of Motive Power. I believe it would be pretty hard to operate a railroad where there is heavy traffic without the mechanical officer having a daily report showing what engines are in the roundhouse for repairs and when they are expected out. With this knowledge he can tell whether it will be necessary to shift the power or whether he can supply the demand without a shift.

The President: Is there anything further on this subject?

Prof. H. Wade Hibbard: May I be permitted to add one radical suggestion in matters of this sort? and that is, the presentation of reports in graphical form. I have recently heard that one of our important locomotive works has just started the practice of a study of the relations of certain departments to the general payroll or to the various costs of manufacturing its locomotives, presenting these reports and studying these reports as plotted on cross-section paper,— plotted as curves or black squares on a checker board, or black bars of different lengths — there are a dozen different ways of presenting that information graphically, so that the official can, at a glance, see the situation and compare it with previous situations, and also that by looking at this graphical presentation of the information he can appreciate the true bearings of that information. Figures, particularly figures of digits, are not so clearly pronounced. I believe that the advance in the study of costs and conditions of equipment, machinery and so on which has been made in certain lines of industries, and is commencing on a few railroads, is the proper sort of advance and that in a few years from now we shall see those reports and information presented in graphical form for immediate and suitable consideration by the official who needs to study the facts.

Mr. Walsh: In line with what was said by Mr. Curtis as to the distribution of power from the various divisions or districts of our system we get a daily report regularly showing locomotives in the shops, when they will be out; in the roundhouse, when they will be out; cost of repairs, etc., and the number of engines awaiting the shop; but as to the distribution of

power upon our system, the Mechanical Department does not enter into that matter. That is a Transportation Department matter and is handled by the General Manager and the Superintendent of Transportation. So when it comes to transferring engines from one division to another, the Motive Power Department is not consulted in the matter, and I believe that is the practice quite generally.

MR. WILDIN: I do not think this applies so much to the transfer of power from one division to another as it does to the knowledge that you have power for the individual division you are trying to operate. I get a telegraphic report every morning showing just what engines are in a certain roundhouse, when they went in and when they are expected out. That, I think, is an essential report.

THE PRESIDENT: If there is nothing further on this subject, I will ask Mr. Curtis to close.

MR. CURTIS (L. & N. R. R.): In closing the discussion on this report I will emphasize what I said before that I think the reports are largely local; and in reply to what Mr. Wildin has said, that he desires to know what engines are in the shop for a short period of time and when they will be ready for service. That is well enough; but I think all mechanical departments are doing all they can to get the engines ready for service and to get this report as to when they will be out does not benefit us very much, as they will be out as soon as they can; and furthermore on a railroad like the C. & O. or the L. & N., where the locomotives are handled by the General Manager and the Superintendent of Transportation, there is but little for the Mechanical Department to do in knowing the exact daily condition of the locomotives. However, this may be done locally to good advantage.

THE PRESIDENT: The next subject is the Proper Width of Track on Curve to Secure the Best Results of Engines of Different Lengths of Rigid Wheel Base. Mr. F. M. Whyte not being here the Secretary will read his report.

THE SECRETARY: I have the following letter from Mr. Whyte, the chairman of the committee:

NEW YORK, June 9, 1908.

Mr. J. W. Taylor, Secretary, Master Mechanics' Association, 390 Old Colony Building, Chicago, Illinois:

DEAR SIR,— The committee of the Master Mechanics' Association appointed to confer with a committee of the American Railway Engineering and Maintenance of Way Association concerning the widening of gauge of track at curves begs to report progress and to suggest that a committee be continued to represent this Association in the joint committee.

Several meetings were held during the year and considerable progress was made, but there remains to be done some work in which a committee of this Association can be of assistance.

Several of the standards of this Association are accepted from the standards of the Master Car Builders' Association, and it is found that some of the standards which are under discussion by the joint committee are those of the Master Car Builders, as shown on M. C. B. Sheet 12, and that, therefore, the joint committee should include representatives from the Master Car Builders' Association. Correspondence is being had with the Master Car Builders' Association suggesting that that Association appoint a committee to represent it in the joint committee.

The study made so far indicates that the subject is an important one and should receive the attention of all three associations.

Yours truly, F. M. WHYTE.

THE PRESIDENT: Gentlemen, you have heard the report. A motion will be in order to receive it and continue the committee.

MR. J. H. SETCHEL: I move the report of the chairman of the committee be received and the subject continued as recommended.

Motion seconded.

MR. J. F. WALSH: What is the subject?

THE SECRETARY: The proper width of track on curves to secure best results from engines of different lengths of rigid wheel base.

MR. WALSH: I would move, you, Mr. Chairman, that in addition to the duties assigned to this committee, it be instructed or authorized or requested to investigate and report with the subject, the cause of locomotive tender derailments.

MR. SETCHEL: I think there is enough in the subject that Mr. Walsh has spoken of to have a committee by itself, and it should not be referred to this committee. I insist on my motion.

MR. DEVOY: Was the motion of the C. & O. seconded?

MR. SETCHEL: Yes, sir, it was.

MR. WALSH: If I did not mention the fact, I certainly intended to make my proposition as an amendment to Mr. Setchel's motion.

THE PRESIDENT: Mr. Walsh's motion is in the form of an amendment and is open for discussion.

MR. GAINES: I realize as well as Mr. Walsh the importance of the question of tender derailments, and I do not want to belittle it in any way. I think it is fully valuable enough to have a separate committee investigate the subject. I really think it would be better not to tack it on to this committee.

MR. DEVOY: If the gentleman's motion is in order, I can not understand in what way it has any bearing on the subject under consideration. I believe a truck can be designed that will run on a rail where there is not anything left but a streak of rust. I do not believe that the rail has anything to do with tender derailments, and I say that, after following the matter up for three years, that we have a truck with no patents on it at all, so I am not selling anything [laughter], that can be made to run on any track. And the question of track, especially in the western country, where there is gumbo soil, or in the Montanas and Dakotas, is a question entirely of what type of truck you put on the track. There are trucks which I have seen which, in my own opinion, would not be fit to run on the New York Central Lines, let alone some of the tracks that we have where you can just as easily get thrown off an engine as not, at, say, forty miles an hour. To my mind, the matter of tender derailments is a matter of trucks and not rails.

THE PRESIDENT: Now, gentlemen, you will vote on the amendment which the Secretary will read in order that you will all understand it.

THE SECRETARY: Mr. Setchel's motion was that the report be received and the committee continued. That was seconded. Mr. Walsh's proposed amendment was, that in addition to the duties assigned to this committee, they be requested to investigate

and report to this Association on the cause of tender derailment. That motion was also seconded.

MR. WILDIN: I do not believe the Secretary has got this quite clear. Mr. Setchel's motion was to continue that committee and this committee was to act jointly with the American Railway Engineering and Maintenance of Way Association. We certainly would not want the tender question to go before that Association.

THE PRESIDENT: Gentlemen, you understand the subject. You will now vote on the amendment.

MR. WALSH: I did not know that this committee was going to act with the American Railway Engineering and Maintenance of Way Association. If that is the case, with the permission of my second, I will withdraw that motion.

THE PRESIDENT: Gentlemen, the amendment is withdrawn, and the original motion is before you, that the report be received and the committee continued.

Upon a vote being taken the motion was carried.

THE SECRETARY: The President has called a meeting of the Executive Committee at the Marlborough-Blenheim to-night at 8 o'clock.

THE PRESIDENT: Gentlemen, the individual paper by Mr. Lawrence H. Fry on "Design and Strength of Crank Axles" is not ready, and we have substituted a paper on "Fuel Economy," by Mr. Willis C. Squire. We will first take up the topical discussion, No. 2, "The Smoke Nuisance — What Is the Best Method of Preventing It?" to be opened by Mr. H. T. Bentley, then Mr. Squire will read his paper in that connection.

Mr. Bentley read the paper.

TOPICAL DISCUSSION — THE SMOKE NUISANCE.

MR. H. T. BENTLEY (C. & N.-W. Ry.): It is not necessary for me to tell you what smoke is, or to say how very disagreeable it can be for those who have to come in contact with it, or what damage it does. Its presence in quantities at the stack shows conclusively that combustion in fire box is imperfect, either by

reason of poor design in the boiler, poor firing, or insufficient air admitted through the grates to furnish oxygen in large enough quantities for complete combustion.

I am not prepared to furnish any new specific for the complete cure of smoke troubles. There are many practical difficulties in the way of consuming smoke, particularly in locomotive service, but they are not always altogether insuperable; that is to say, under ordinary conditions, the amount of smoke emitted can be so small as not to be objectionable. The principle involved is that of mixing air with the combustible vapor and gases generated by the action of heat on the fuel so that by a proper supply of oxygen being furnished they may be made to burn with flame and become entirely converted into combustible and invisible vapors and gases.

Having a large number of locomotives working in and around the city of Chicago, where the smoke inspection bureau has a staff of very active inspectors always on the lookout for violators of the smoke ordinance, we have tried nearly every scheme that has been suggested, or that we could think of, having a man specially qualified to watch results.

When reporting on any particular device we have invariably been told that "It is a good thing if engine is properly fired," which brings us back to the personal equation; it has been our experience that no device we could put on an engine would do much good if engine was improperly fired.

We do not believe that it is possible to entirely eliminate all of the smoke at all times from a locomotive burning bituminous coal, on account of the nature of the service; first working at full stroke, then at short cut off, and suddenly being shut off entirely on account of being stopped by a signal, just as enough coal has been put in fire box to take the train up a grade or out of the way of a quickly following train; but we do say, that by careful firing, more than anything else, and a close working understanding between engineer and fireman, the amount of smoke emitted need not be of such an amount as to be open to serious criticism.

We have used so-called smokeless coal with fairly good results, but it is not entirely free from smoke, and has given us

trouble in other directions. Have also tried coke, which is free from black smoke, but the fumes emitted are very objectionable.

In concluding we believe the smoke nuisance can be reduced to a minimum by the following: Coöperation on part of engine crew, careful firing, the use of a brick arch, coal properly broken up, engine and grate area of sufficient capacity to do the work required without crowding, grate openings large enough to supply the proper amount of air.

I have read in some of the Chicago papers that several of the eastern and some of the western roads have some new scheme for entirely eliminating black smoke. I am very glad to hear of it, and am going to get in touch with the roads mentioned so as to get some information on the subject, because we are very anxious to cut out black smoke if we can. They tell me that they are so well satisfied that they have photographers out on the road taking photographs to show how little smoke is emitted.

THE PRESIDENT: Mr. Squire, if you will come forward now we would like to have you read your paper.

MR. W. C. SQUIRE (Old Colony): Mr. President, this paper on "Fuel Economy" is a presentation of several devices that have been recently developed abroad and at home to accomplish just what Mr. Bentley calls for: the admission of the proper amount of air into the fire box, to improve and complete combustion. Necessarily when you improve or perfect combustion you reduce materially the amount of fuel consumed to develop the same amount of work with your engines. The paper is somewhat historical in its dealing with the subject matter in that it touches generally on what has been done in the past and calls particular attention to specific developments abroad, comparing them with similar devices we are using here at home.

FUEL ECONOMY.

SOME RECENT IMPROVEMENTS IN AMERICAN AND EUROPEAN LOCOMOTIVE PRACTICE FOR EFFECTING IMPROVED COMBUSTION AND SMOKE PREVENTION.

BY W. C. SQUIRE.

This general topic has been discussed in some of its many and varied phases at every convention of the Association for a decade. Our annual proceedings for years past have had more or less of its pages filled with valuable technical and practical data bearing on this subject, all tending

to instruct us to know how best to accomplish the desired end, viz.: the conservation into useful work of the available energy in B. T. U. contained in our bituminous coals.

It is not the intention in this paper to deal with the technical or theoretical side of the question except in such manner as may be necessary to prove a point, but will show in diagrams and illustrations some of the recent practical methods that have been followed to solve the problem at hand.

It is conceded that the greatest amount of B. T. U. is transferred to the water, when the combustion is perfect and the rate of combustion is relatively low, that is, when the product of combustion is practically all $C. O_2$ carbon dioxide, and there is present in the outflowing gases little or no C. O. carbon monoxide or black smoke interspersed with cinders or unburned coked coal.

The committee reports on front end arrangements, draft appliances, self-cleaning front ends and the Pennsylvania R. R's. locomotive tests at St. Louis on coal consumption are recognized as standards for practical and basic law as regards these fundamental parts of the boiler. Much of this committee work is the record of original investigations made at great expense and is truly worthy of our highest admiration because of the unselfish ardor and zeal of our members in preparing it for our use. From these records will be taken such data as may be needed, and, with the practical developments of to-day, it is hoped to show that there is a practical solution of the problem of perfect (smokeless) combustion.

From personal experience dating back some years on one of our western railway systems there is gleaned some striking coincidences in practice with that being carried on abroad during the same period, and also in various parts of America. The late C. M. Higginson, investigating fuel matters on the Santa Fe System, some years ago contended for the proposition that smokeless burning of fuel in stationary or locomotive fire boxes could only be accomplished by admission of a requisite amount of air into the fire box by other means than through the grates and their covering of burning fuel.

His experiments covered a wide range of investigation, using numerous combinations of air inlets, perforated brick arches, blowers, checkerwork arches, combustion chambers, etc. Unfortunately for us, Mr. Higginson did not live to finish his investigation and his work was not carried on to completion and was finally dropped.

From this particular line of experiments, as well as many others of which we have record, we see a similarity in the efforts made to accomplish the desired end, indicating that those whose attention was given to this subject seemed naturally to drift to the same general solution. We appear to have advanced in all these investigations until that period was reached which promised a successful issue of the experiments: here

either funds or inclination gave out and the results were lost except to the individuals immediately interested in the tests.

For twenty years and more the larger cities of the world have been belaboring, among other industries, the railroads, trying to force them to reduce the smoke made by their locomotives running within the corporate limits. Drastic laws and ordinances have been enforced by special officials and by other means to the end that the roads were periodically forced to apply good, bad and indifferent methods to prevent prosecution by law and persecution by the daily press. None of us who are honest with ourselves but will acknowledge that the great clouds of smoke issuing from the locomotive stacks were a nuisance first, last and always.

Among the first methods tried to prevent smoke was the continuous use of the blower in connection with a generous fire door opening. We also instructed the fireman to fire lightly and with good judgment. This was followed closely by the injected steam and air into the fire box, usually over the top of fire through thimbles perforating the water leg,

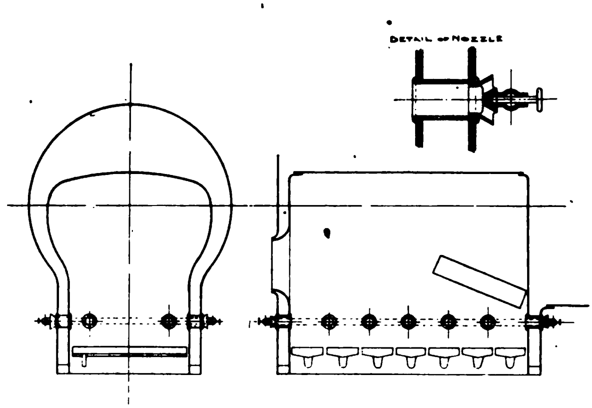


FIG. A.

then came the single scoop and double scoop methods. These devices and methods were also used in combination with plain fire arches of various kinds and makes.

At some critical period in the recent past, our operating officials realized that the coal pile was one of the largest individual items of expense, being approximately fifty per cent of locomotive expense for maintenance, and from motives of economy, we, the mechanical officials, saw the necessity of reducing the cost of fuel per engine or train mile. We took up willingly what before was forced upon us and yet we did not entirely solve the problem. Interests outside of railroad, but with official encouragement, began the solving of the problem in the United States, while abroad the solution was in the hands of some of the

advanced mechanical officials. Public opinion, government supervision and general agitation toward forest conservation, reduction of floods and other natural causes led to the serious consideration of the reduction of fire losses caused by the "locomotive sparks."

The way to prevent sparking is either to burn the cinders or not make them. This latter proposition is not entirely feasible in locomotive practice, as the heavy intermittent forced draft necessarily raises the smaller particles of coal from the grate bed, and these particles are carried with the gases into the flues and out of the stack.

Our self-cleaning front ends and the means we have generally adopted, have brought about a condition we do not in the least desire; but actual service is such that we have accepted what we believe to be inevitable and the result is that we have in general use locomotives that smoke and throw cinders.

Tests made on the Purdue testing plant and later on the Pennsylvania R. R. plant at St. Louis, in 1904, have shown that from four per cent to fifteen per cent of all coal burned may be accounted for as cinders and sparks. Thirty-three per cent of all the cinders and sparks made were retained in the front end, ranging as high as sixty per cent. From Prof. Goss' "Locomotive Sparks," his conclusions are that spark losses are greatest when the rate of combustion is the highest and the draft is highest, but this is also affected by the character of the exhaust. In connection with narrow fire boxes worked to maximum capacity the spark losses increase to twenty per cent. The character of coal has a great deal to do with the amount of sparks produced, a light and friable coal giving the greatest percentage of sparks.

The Pennsylvania R. R. tests, however, show from 4 per cent to 25 per cent of coal fired accounted for as sparks and cinders. The American engines tested show the lowest ratios when compared with the foreign engines tested at St. Louis. The compound engine spark losses are away below those obtained from single expansion engines for total sparks thrown and caught.

The difference between the American and foreign engines tested may be accounted for by the fact that our American engines were built for American coals and foreign engines built for foreign coal.

Mr. Wm. Garstang's paper presented at the Western Railway Club on "Tests of Coal for Locomotive" give results obtained from five kinds of coal; three tests are reported for each coal. The ratios of sparks to coal burned vary from 5 per cent to 23 per cent, and strange to relate, there is shown but a small difference in the ratio obtained from speeds of 30 and 50 M. P. H.

It can be taken as a general proposition that the greatest spark losses are obtained with the highest rate of evaporation per foot of heating surface per hour. The spark losses from the lignite coals of the west and southwest must be considerably in excess of all the results so far tabulated and recorded.

From the Purdue test and those at St. Louis it is seen that cinders and sparks have from 75 per cent to 90 per cent the heat value of dry coal. Three and one-fourth per cent to 4⅓ per cent of the contents of sparks is volatile matter, and from 18½ per cent to 32 per cent is ash. These results are obtained with Brazil, Indiana, coal, and was determined from the tests made on the Purdue locomotive testing plant.

Prof. Goss' tests also show that the fuel value of a unit of sparks and cinders increases as the volume discharged increases, and that the size of the sparks ejected varies with the total amount produced. The greatest amount of sparks fall in an area lying between 35 and 150 feet from center of track, and concludes that the possibility of fires is greatest in these limits; local conditions he claims, due to air currents, may have influenced during his observations the non-lodgment of sparks nearer the track. Beyond 125 feet the sparks were found to be of such character as to preclude any possibility of their setting out fires.

More fires are set by the sparks of locomotives in seasons of drought than at any other time of the year. This fact is generally acknowledged, because forest and prairie fires and similar conflagrations occur in periods of drought. Fires burning along the right of way are noticeable in the fall of the year, showing that they have been coincident with the passing of the locomotive as the fires are isolated and incipient and decidedly local. The carrying capacity of sparks is not dissimilar to that of brands from burning buildings. At night these sparks can be seen floating away and dying out while suspended in the atmosphere. The coal used has much to do with this peculiarity, and sparks from lignites seem to burn more nearly like wood sparks than those from any other coal. Lignite sparks when thrown from the stack of a hard-working engine are not dissimilar to the so-called flower pot of set piece fireworks.

While we are discussing the conditions at home the European railways are fighting their own battles in their own way, as is evidenced by the following item published some time ago and is taken from a German periodical, the *Zeitung des Vereines Deutscher Eisenbahn verwaltungen (Magazine of the Society of German Railway Managements.)* "Prevention of fires: The Prussian Minister for Public Works has directed by an order issued to the Royal Railway Managements as follows:

"The numerous fires recently caused by sparks thrown from locomotives have been called to my attention, and I direct that the Royal Railway Managements shall most carefully supervise the means taken for the prevention of such danger from fire. While I have to acknowledge the difficulties which tend to prevent entirely the throwing of sparks by locomotives, especially when heavy train loads are hauled, nevertheless it will be possible by careful enforcement of existing rules to prevent ignition in particularly dangerous places, such as occur in open spaces, or in extensive forests and in the vicinity of villages and towns, etc. I again call the attention to orders which I have previously given, and I trust

that the Royal Railway Managements will fortify themselves by taking prompt and efficient measures to prevent fire from locomotive sparks.

"Rigid inspections during the existing exceedingly dry season must be made of all locomotives, before they are put into service by the Inspectors in charge, to whom this service is confided, looking especially to the apparatus for prevention of sparking, such as spark catchers, and must see that ash pan dampers are provided and that they are in good working order. Drivers and firemen are especially to be directed in accordance with the rules, that they personally give supervision to these points, and they are to be advised that the strictest following of the service regulations for locomotive drivers according to Rule 27 of the Service Instructions are to be enforced. If these rules are not strictly obeyed, most severe discipline will follow their infraction. When locomotives throw more sparks than ordinarily, it is the duty of all railway employees, especially the engine drivers, to report same. immediately, in order that the locomotive may be rigidly inspected. I expect from the inspectors and experts the most careful consideration and execution of the existing rules and to give them their personal attention. After four weeks from date, reports are to be made, as to what special measures for prevention of fires should be made."

In July, 1904, there was published in Germany some data and information on locomotive front ends relative to sparking and the deleterious effects of the self-cleaning devices on draft.

The conclusions arrived at in this article confirm those of Prof. Goss as regards the rate at which cinders and sparks are made, i. e., the greater the rate of combustion, the greater the amount of steam made per unit of heating surface and the greater the ratio of sparks to total coal burned.

The actual retaining of all cinders and sparks in the smoke box is deemed impossible and impracticable, and objections are held against the introduction of baffles, deflectors and netting, as they reduce materially the draft caused by the exhaust. The writer of the above sagely remarks that "every obstacle placed in the way of steam generation is a logical error," referring more particularly to the reduction of draft through the flues by use of cinder retaining devices.

It is stated that in Germany there are some sixty or more patents on spark arresters alone. They only effect a small decrease in sparks ejected, and that at a cost of the effective draft, resulting in deficient steaming.

Self-cleaning front ends are recognized in continental European practice as a necessity, owing to the fact that their expresses and high speed locomotives throw out such volumes of sparks that they must be ejected from the front end, otherwise the engines will not steam.

About ten years ago Mr. Karl Schleyder, then in charge of motive power on the Austria-Hungary State Railway, urged by public clamor and more particularly by government regulations and rules, commenced

a series of experiments with brick arches, looking toward smoke elimination, reduction of cinders ejected from the stack and also to secure as great a saving in fuel consumption as possible. From single arches he went to a series of arches, whose function was to force the oxygen, hydrocarbon gases, cinders, etc., into more intimate connection with each other to insure their mixture and consequent combustion before they reached the flues.

In Figs. 1 to 8 will be found some diagramatic outlines of the mul-

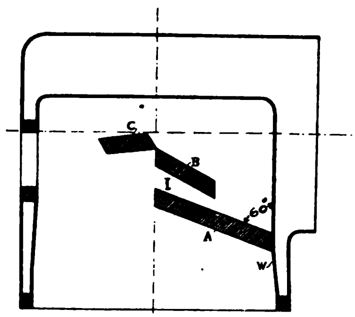


FIG 1

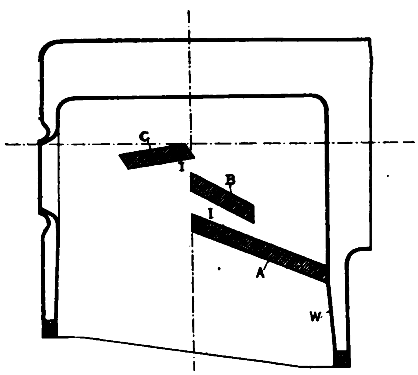


FIG 2

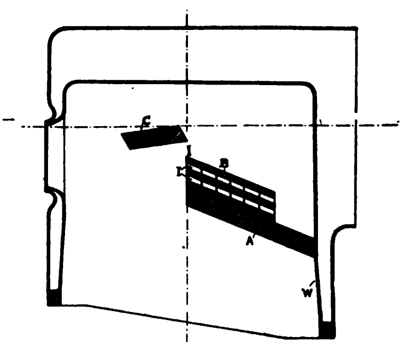


FIG. 3.

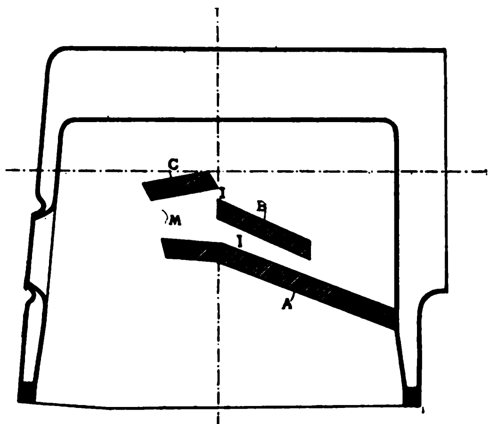
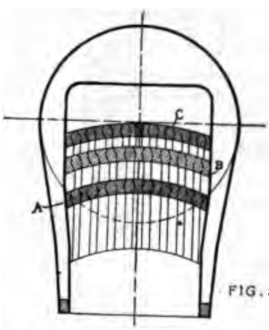
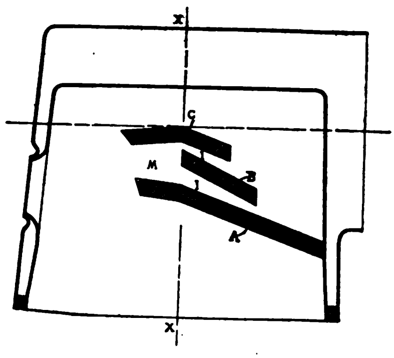


FIG. 4.



SECTION X-X

FIG. 5.



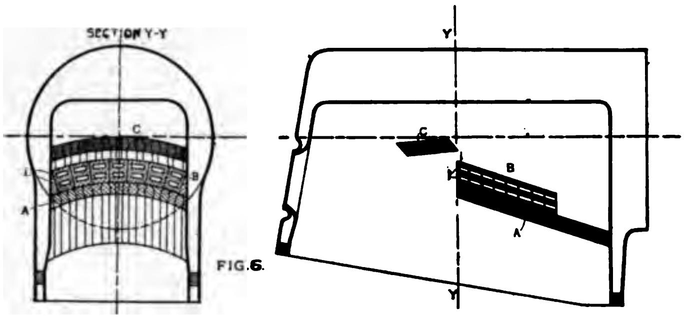
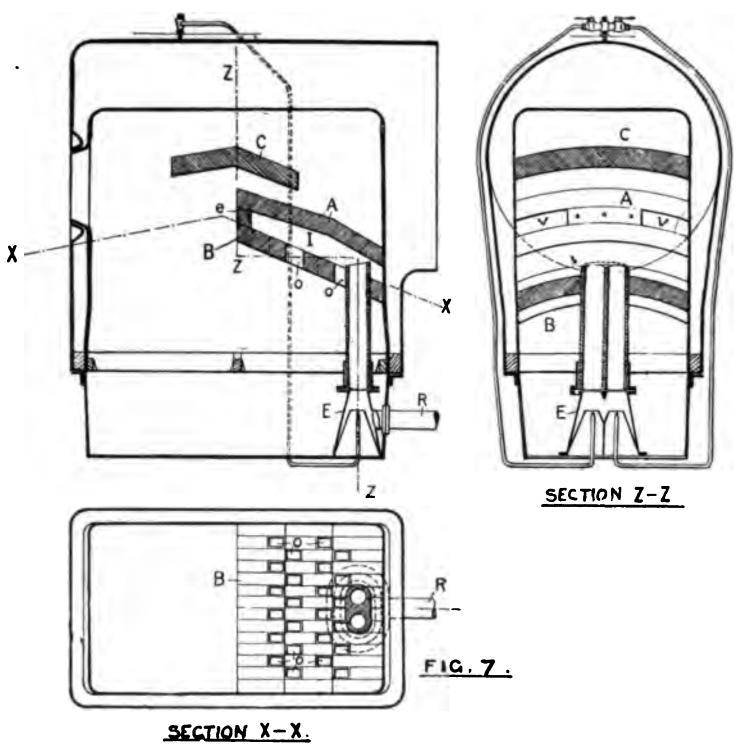

SECTION Y-Y
C
B
A
FIG. 6.
Y
Y
C
B
A

FIG. 6.


Z
C
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SECTION Z-Z
B
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FIG. 7.
SECTION X-X.

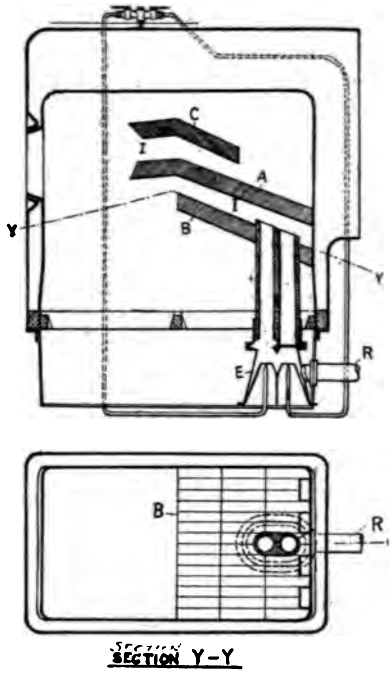


FIG. 8.

tiple arch construction that were tried out. The investigations demonstrated the fact that if the gases could be diverted and forced through a series of flame ways with relatively narrow converging openings there was better combustion than if the flame ways were diverging. The heat in the arches, as would be expected, assists materially to heat the oxygen and other gases to the igniting point, besides intimately mixing them by the longer contact with the arch surfaces.

Fig. 3 shows a variation of Fig. 2 where arch B is composed of a series of hollow brick with many perforations but of sufficient cross area to permit combustion to continue while gases flow through the apertures.

Fig. 6 shows an arch construction similar to Fig. 3 for a long fire box. A noticeable feature in all these designs is that the highest point in top arch is usually coincident with the center line of boiler and that the top of fire door is also close to or coincident with the center line.

With all the arches shown it was found that if a relatively large volume of air was admitted into the fire box through the fire door, combustion was improved. In some of the designs tried out, the door was composed of a series of truncated cone of steel plate placed eccentrically so that the openings at the bottom were larger than at the top. This was

supposed to allow more air to flow to the lower portion of fire box than to upper. The door, however, was run into the box somewhat beyond the door sheet and so became heated. The incoming air being divided into thin layers took up the heat in passing over the great area of sheet metal of which the door was made. That the air did become heated is proven by the long life of these doors, showing the air took up the heat and prevented burning of the plates. Another door was made of a large number of flues. Their general construction is shown in Fig. 9.

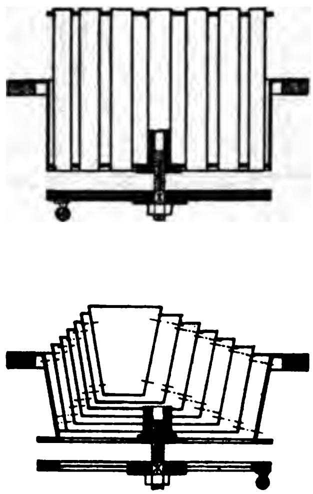


FIG. 9.

From the construction of the type of arches shown in Fig. 3 and Fig. 8, the design of arches shown in Figs. 7 and 8 were evolved. Here arch B was placed below main arch A and run back to the flue sheet. To secure a better circulation of gases and to use all the arch surfaces, the arch B was perforated and a portion of the back aperture between B and A was closed as at E.

The next logical step was to bring in air from outside the fire box so as to be able to use the combustion chamber between arches A and B as shown in Figs. 7 and 8. To accelerate the flow of air into the fire box, steam blowers were placed at the lower end of the inlet pipes to supply air when engines were not using steam.

This evolution brought the next logical step. With a blower to force air into the fire box, the intake pipe could be continued to the front end and connected with a hopper to the smoke arch. Therefore, cinders finding their way to the front end would be directed to the hopper by the deflector plate, and the induced current in the pipe R which, having a less pressure than that in the smoke box, the cinders and some

of the front end gases would be returned to the fire box, thence into the hollow arch, and being mixed with air from the outside taken in at the lower portion of the intake pipe, a two-fold action was accomplished — smoke was eliminated by admission of air, and cinders were returned to the fire box to be consumed.

It has been claimed by some of the railroad officials using this device abroad that the return flue R carried all the black smoke and as well as all the cinders from the smoke box back into the fire box. As the area of the return flue R is about one-quarter that of the stack and one-twentieth that of the flues, the impossibility of the proposition is apparent. There is, however, no doubt about the cinders; the major portion are returned to the fire box. That some small cinders and ash are ejected with the front end gases there can be no question.

The double tubes shown in Fig. 8 were replaced later by a single tube, Fig. 10. It was early demonstrated that the injected cylinders striking the bottom of the arch had a sand blast effect on the brick, cutting through it in a very short time. Then the brick immediately above the tube was replaced by a cast steel or cast-iron baffle plate, arches B and C were discarded and arch A was made to suit the conditions of the fire box and fire-door openings.

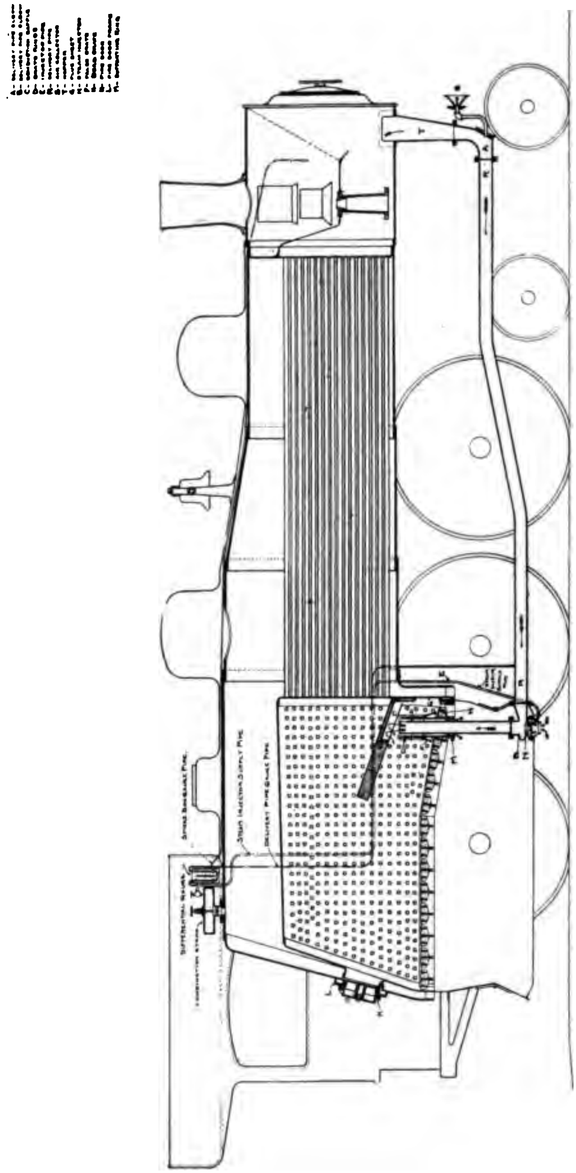


FIG. 12.

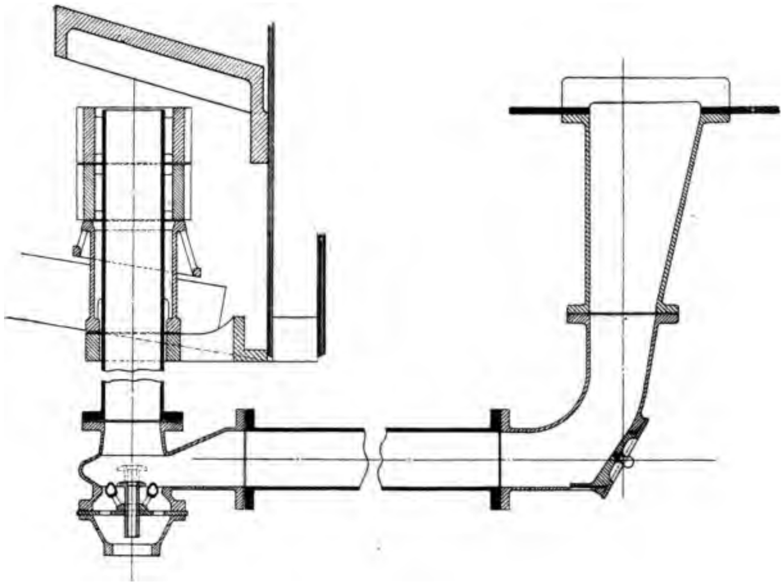


FIG. 13.

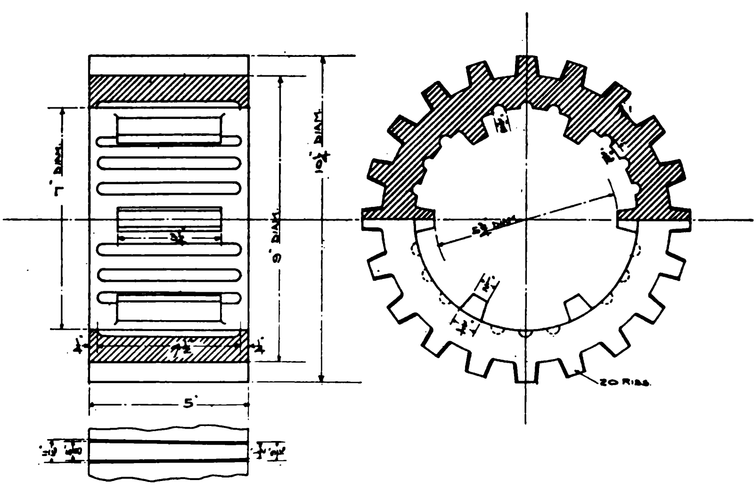


FIG. 13-A.

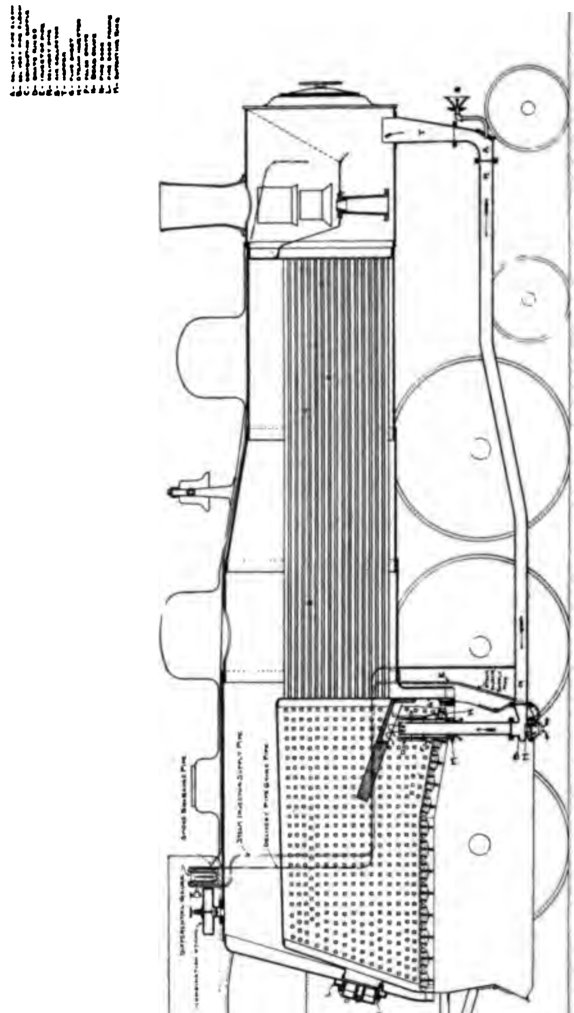


FIG. 12.

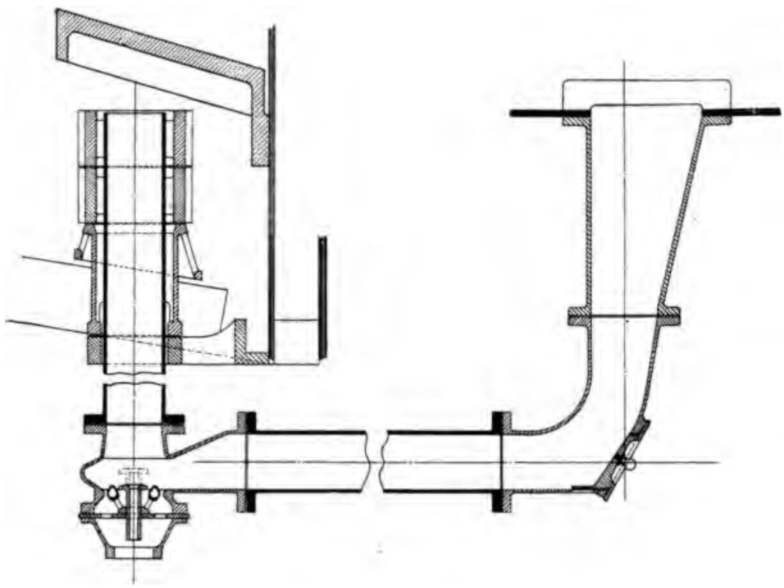


FIG. 13.

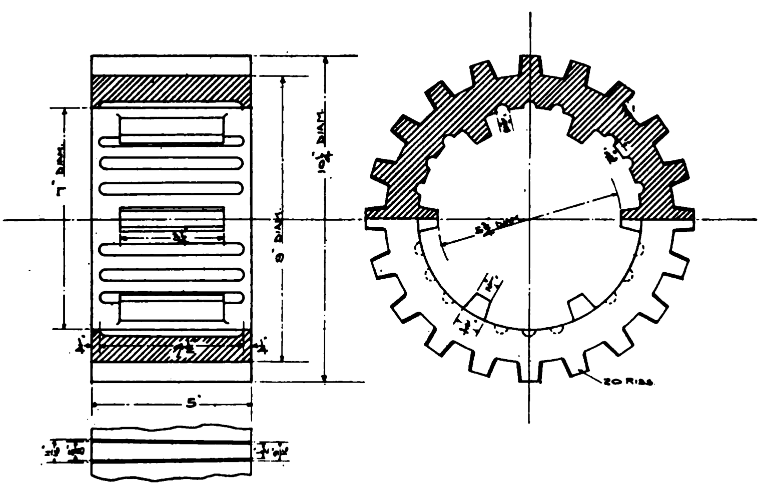


FIG. 13-A.

Fig. 11 shows the complete device as used to-day on the Austrian State Railway. Fig. 12 shows the application to a modern 4-6-0 (ten-wheeled) passenger engine in use on one of our important eastern railroads.

Fig. 13 shows in a diagrammatic way the whole device.

To prevent the intake pipe burning out, around the intake pipe are placed the cast-iron rings, Fig. 13-A. These rings are made of grate stock cast iron. When burned they are turned one-quarter-way around in about every four to six weeks. They usually burn out on the face toward fire door, and from records at hand they have lasted from three to six months in daily service.

Mr. F. Elbel, General Supt. of Railway Construction, in an article in the *Railway Workmen*, of January 15, 1904, speaking of arches and their effect on the fire, says: "It is quite evident that the greater the resistance offered to the flame gases and cinders, and the longer the heat is retained in the fire box, the more advantageous will be the effects of combustion, consequently, such devices must result in more complete combustion." In commenting on the Schleyder apparatus Mr. Elbel makes the remark: "I will state that the (baffles) fire arches are not an absolute necessity for the proper working of the apparatus. The cleaning of flues and smoke arch is entirely eliminated, being cleaned automatically. A distinct saving in fuel results, any kind of coal can be used, with no smoke or cinders, and engines steam freely.

From the Table A, presented herewith, being the results of a six months' test, there is shown a distinct fuel economy of 13½ per cent and a difference between the cinder caught in smoke box for that period of 11.25 baskets for the equipped engine to 237.75 baskets for the non-equipped engine. It is evident from these figures that these engines do not have effective self-cleaning front ends.

THE ROYAL & IMPERIAL
HEATING DEPARTMENT
WESTERN RAILWAY
VIENNA I.

FUEL ECONOMY.

COMPARISON OF COAL CONSUMPTION AND CINDERS COLLECTED FOR A PERIOD OF SIX MONTHS

LOCOMOTIVE No. 15947 FITTED WITH THE SCHLEYDERS SYSTEM AND LOCOMOTIVES Nos. 15948 AND 15961 FITTED WITH MAREK SYSTEM OF ARCHES.

Month	Number of Locomotive and Type of Equipment	Train and Engine Statistics				Coal						Residue in Smoke Box in Baskets
		Train Miles	Total Locomotive Miles	1000 Ton Miles	Average Tons Hauled per Train Mile	Bohemian Middling I and II	Bohemian Nut I	Libuschiner Lumps	Reduced to Normal Coal Standard	Per 1000 Ton Miles	Per Locomotive Mile	
						Tons - 2000 Lbs.				Pounds		
January	Loco. 15947	1193.65	1590.08	525.11	485.0	10.5	57.3	—	63.62	242.23	79.92	2.75
	Loco. 15948	613.29	900.36	257.87	464.1	22.0	13.6	0.55	36.37	282.14	80.78	29.75
February	Loco. 15947	1005.37	1374.47	450.68	493.8	22.0	33.1	—	53.35	236.76	75.48	1.5
	Loco. 15961	994.19	1434.74	434.83	481.7	50.2	7.2	—	58.75	270.22	81.86	37.0
March	Loco. 15947	1088.02	1486.54	483.41	489.4	38.0	18.2	—	56.28	232.76	75.48	2.0
	Loco. 15961	1098.58	1421.69	458.32	459.7	47.4	8.8	—	57.41	260.50	80.78	42.0
April	Loco. 15947	1340.29	1561.50	653.87	537.9	3.9	65.6	—	64.35	188.20	82.20	3.0
	Loco. 15961	1094.85	1458.74	518.39	521.4	52.9	11.0	—	65.70	253.36	87.52	36.0
May	Loco. 15947	1728.65	2036.23	846.85	540.1	—	74.4	—	68.45	161.65	66.98	1.0
	Loco. 15961	1624.26	1828.07	753.50	511.6	34.7	52.4	—	84.28	223.32	92.12	47.5
June	Loco. 15947	1516.14	1742.32	688.44	508.2	—	69.4	—	63.89	182.96	73.34	1.0
	Loco. 15961	1486.32	1913.82	731.97	542.2	—	72.2	—	66.42	181.49	69.46	45.5
Total or Average	Loco. 15947	7872.13	9791.25	3658.55	505.3	74.4	318.0	—	369.56	202.24	75.48	11.25
	Locos. 15948 and 15961	6811.50	8595.44	3155.50	497.1	207.2	165.1	0.55	368.94	233.84	81.86	237.75

THE ACTUAL SAVINGS SHOWN ARE 31.6 LBS. OF COAL PER 1000 TON MILES OR 13.5%.
IN 6 MONTHS THERE WERE REMOVED FROM THE SCHLEYDERS ENGINE No. 15947 11¼ BASKETS OF CINDERS FROM THE SMOKE BOX, AND FROM THE MAREK ENGINES No. 15948-15961, 237¾ BASKETS OF CINDERS FROM THE SMOKE BOX.
STANDARD OR NORMAL COAL WILL EVAPORATE 4 LITRES WATER PER KILOGRAM, IN ROUND FIGURES – 4 LBS. WATER PER 1 LB. OF COAL.

TABLE A.

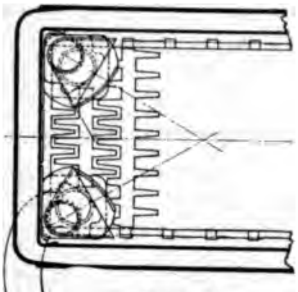


FIG-14

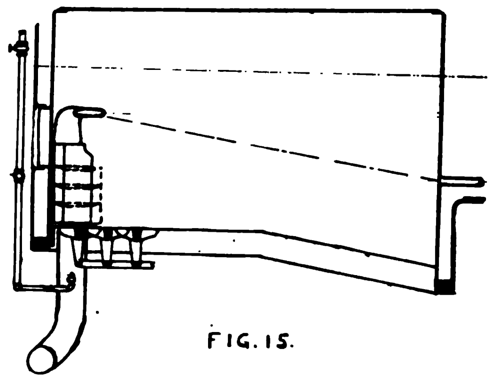


FIG. 15.

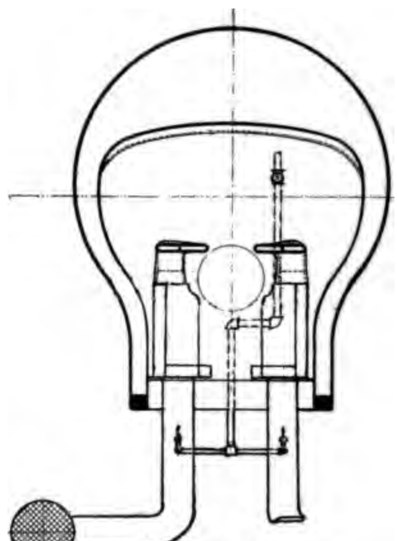


FIG. 16.

There is also in use to-day a device that is similar in many respects to the device just described, which was developed in New Jersey, but which does not use the brick arch, claiming it to be unnecessary. Reference is particularly made to the Parsons device, see Figures 14, 15 and 16. This device uses two intake pipes, called heater boxes, placed in the back corners of the fire box and terminating in two flat nozzles with long narrow vents so constructed as to approximately converge the two incom-

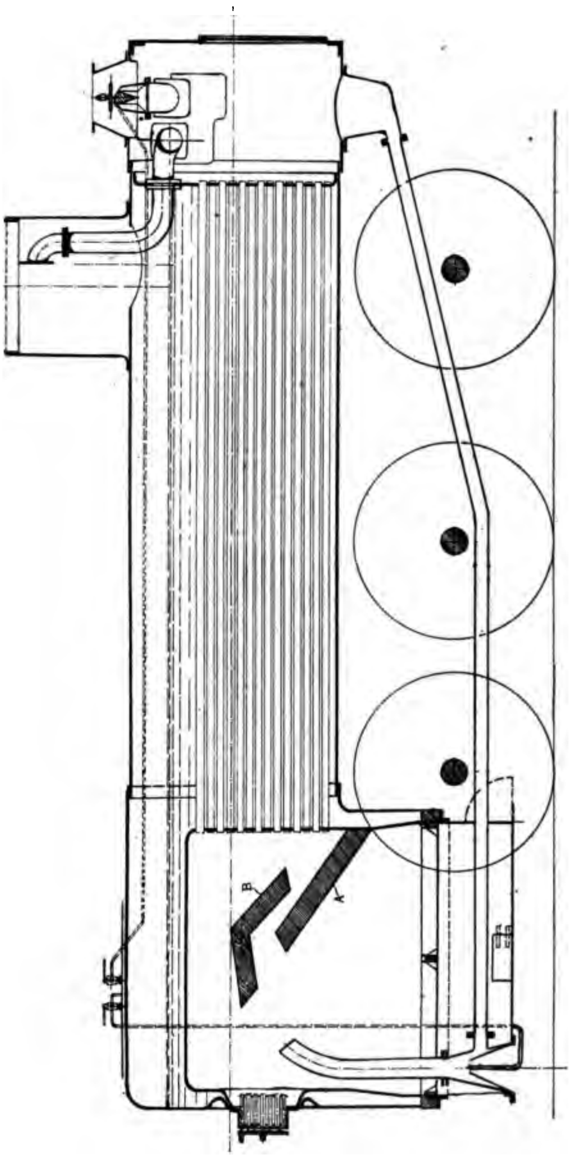
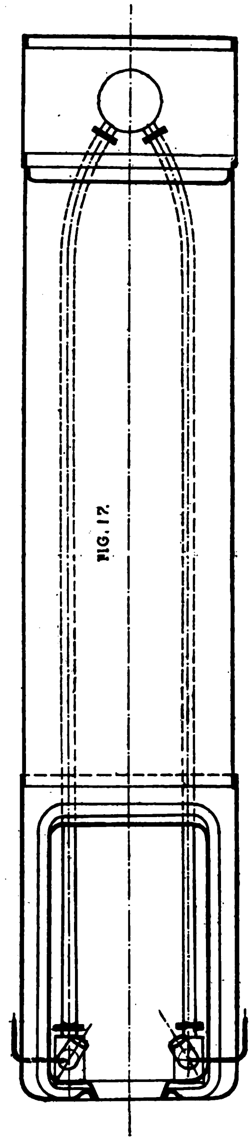


FIG. 17.



M-9

ing jets of air about one-third to one-fourth the length of fire box, and also to direct the air toward the lower or bottom rows of flues. The heater boxes are protected by rings of fire brick. The bottom of the heater boxes below the grate are connected with intake pipes terminating in funnels or air scoops arranged outside the wheels as shown in Figs. 14, 15 and 16.

When standing at stations or running without steam, air can be forced into the fire box by means of steam blower pipes placed inside the heater boxes as shown. As stated above the two devices are similar in general design in that air is taken into the fire box through tubes opening out into the atmosphere. The Parsons uses the nozzles to direct and divert the air over the grates and coal, and depends upon the difference in pressure in fire box and the outside air to force the air into fire box when running. Standing or drifting, the blower acts the same as in the Schleyder device. The Parsons device does not return cinders from the front end or smoke box, nor does it use the arch. The use of two heater boxes at the back end of the fire box is quite similar to that used by Schleyder in his arrangement for wood fires, see Fig. 17. In this instance, the multiple arch is shown and the intake pipes are connected with the front end to remove the cinders.

Your consideration of the type of brick arch known as the hollow arch, or the Wade-Nicholson arch, is now desired. This arch is made up of hollow arch bricks, receiving air from the outside of the fire box through ferrules perforating the water legs.

The Wade-Nicholson hollow arch is the result of some years of earnest development. The nature of the coal and the type and dimensions of fire box are carefully considered. Air is admitted to the hollow cores in the arch through ferrules, preferably placed in the side sheets or through the throat sheets. The type of the orifices in the arches are shown in the cuts, Figs. 18, 19, 20 and 21. Arches are either supported on water tubes or studs.

In connection with the hollow main arch are the door arches shown in Fig. 18, air being admitted over the door through two 2-inch ferrules or air inlets; the main air arch has two air inlets of two 1/4-inch ferrules. Two types of arches for long fire boxes are shown in Figs. 19 and 20, used in connection with the crown arches placed adjacent to the crown sheet and, being hollow, the air is admitted through the ferrule in the side sheets. In Fig. 19, the air for the main arch is taken through the throat sheets, and in Fig. 20 the arch is set back 18 inches from the flue sheet. This space is bricked in on top of the grate. This is a very shallow fire box; there is no room for the usual construction of arch. By this construction is formed the combustion chamber, which cuts off a portion of the grate area, resulting in combination with the crown arch, of a very efficient arch construction. Air is admitted to the arch from the ash pan in this particular design.

With the hollow arches just described, the amount of air admitted

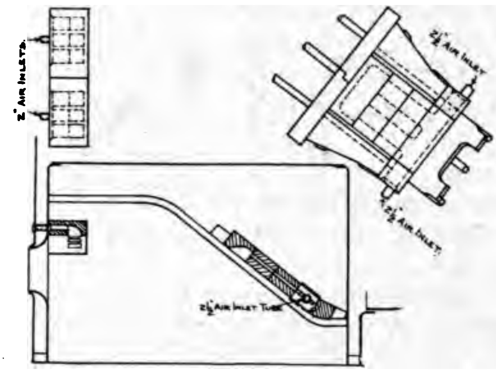


FIG. 18.

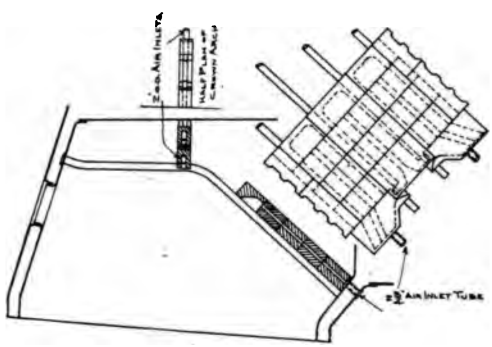


FIG. 19.

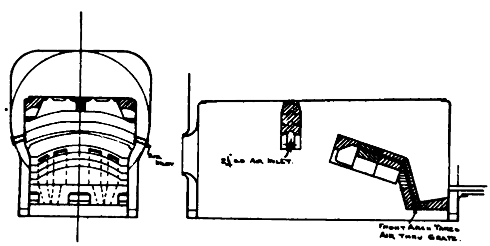


FIG. 20.

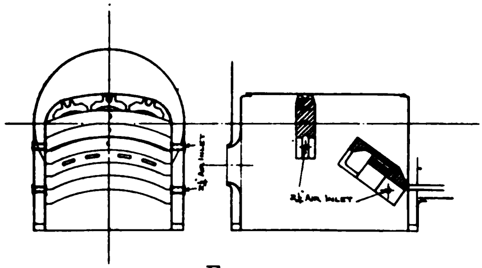


FIG. 21.

to the fire box is limited by the areas of the ferrules, but that which is admitted is heated to a reasonably high degree and improved combustion results, which results are known to be greatly in excess of those secured with plain arches. Tests made by disinterested investigators have shown on engines equipped with the hollow arch an economy approaching 20 per cent over similar or same engines without the arches.

Plain arches are conceded to give an economy approximating 10 per cent over engines without arches. But plain arches have had their advocates and opponents, who have fought for their use or retention, as their dictates led them. There are many points in favor of their use; there are strong arguments against their continuance.

I am reliably informed that similar designs of arches for smoke preventions were in use in Cincinnati Yards in 1884. Leroy Kells, then located at Cincinnati, used hollow arches in switching engines. His results were said to show economy in coal consumption and a marked reduction in smoke. I have not been able to secure data on these tests.

The fact remains, however, that with arches from 10 per cent to 20 per cent economy is possible, and where the cinders are also returned to the fire box, there is an opportunity for still further savings in fuel, and not the least of the benefits derived from any and all of these devices is that of the elimination of smoke. Those that can and do eliminate both the cinders and smoke are worthy of our careful study and consideration.

[Applause.]

MR. E. W. PRATT (C. & N.-W. Ry.): Mr. President, the suggestion was made at the Master Car Builders' convention — and for fear that it should not hold over, I would like to repeat it here, that papers, particularly individual papers, which do not require the meeting of committees, be prepared and printed in sufficient time to be distributed to the members before the convention.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): Mr. President, the question of smoke prevention is one that we have with us and one that must be given serious consideration whether we like to do so or not. We have been following this for a good many years and have, in a measure, been successful in preventing smoke, but all of our efforts and all of the appliances we have been able to use in connection with smoke prevention require a large amount of assistance from the engineer and fireman if proper results are obtained. I believe that the methods referred to in the paper are in the right direction, and also that there are other methods that can be equally well employed. Among the methods and appliances that are necessary for the prevention of smoke are that, as far as possible, similar coal, and coal prepared in about the same way, shall be delivered to a certain district and to one class of men in order that they may become familiar with the use and peculiarities of the particular coal. The injecting of air and steam in jets over the fire, a well arranged brick arch and a strong blower arrangement are necessary factors in smoke preventing devices, and where, with a heavy fire, a locomotive is shut off the blower arrangement must immediately be applied if smoke is to be prevented. In addition to the city inspection that we are subjected to we have found it necessary, as explained by Mr. Bentley, to keep a man constantly in the field looking after the emission of smoke from engines, and we have also found it necessary to give the man a good deal of authority in the matter of his power over the enginemen. When he comes to an engine and finds the smoke preventing appliances in good order and the engine still emitting black smoke, he decides whether the engineer or fireman is the responsible party for that condition, and he takes such action as is necessary, even up to a long suspension. I had the question of the necessity for our getting in line in this matter very forcibly impressed upon me about a year ago. A gentleman with a blue suit and a big star on his breast walked into my office and served a warrant on me, and next morning I had to appear among the drunks and disorderlies at the police court [laughter] to answer to a charge of smoke emission by one of the locomotives of the company which I represent. My plea in the case was that the man had been taken out of the service about three days before the warrant was served. That

appeased the wrath of the court, and I was dismissed. But I still believe that the engineers and firemen are such a strong factor in the success of any smoke preventing device, that it is necessary they should give all the assistance possible in order to get results.

MR. GAINES: Mr. President, there was a paper read — I believe it was before the American Society of Mechanical Engineers at their Detroit meeting, I am not positive about that, but at any rate published recently, in which quite an extensive investigation was made of the proper combustion of soft coal very thoroughly gone into, and from experiments made and also from the Government's report on the same matter, the indications are that if we want to burn soft coal without making smoke we must keep our gases at a high temperature until they are consumed. To do that in stationary practice they have advocated a very great number of arches, baffle plates and things of that nature, entirely different from the present stationary practice; and I believe they have gotten some very beneficial results along those lines. I have not tried the Wade-Nicholson arch referred to here, but that seems to be a little along those lines, that is, keeping the hot gases away from the colder sheets in contact with the water until thorough combustion takes place.

MR. PETER H. PECK (C. & W. I. R. R.): Mr. President, I am in the same boat with Mr. Manchester. In Chicago it is all terminal, and we have a dozen or fifteen smoke inspectors all the time, and every time there is black smoke it is a hundred dollars per, so that we are all paying attention to it and working on it. I have tried, I think, every kind of smoke device that was ever built. The last I tried was the one found on pages 19 and 22 of the report, and is the one referred to by the last speaker. There is a brick arch that hangs down from the crown sheet. I think the North-Western Road has also experimented with it. It is the best I have tried yet, not only the best but the cheapest. To install that in an engine the first time costs only about $12. After that it is about $3 an arch, and the arches probably last, the top one about four months and the bottom about two months. I have tried arches in every conceivable way. Some side sheets in my old boilers look like porous plasters.

They have holes punched in all of them for combustion, but they are still there and they are still smoking. [Laughter.]

The President: Mr. Manning, how is it up around Saratoga?

Mr. J. H. Manning (D. & H. Co.): We are using anthracite coal, I am pleased to say, Mr. President, and we have no trouble with smoke.

The President: Is there any further discussion on this subject?

Mr. Angus Sinclair: Mr. President, I have paid considerable attention in my time to smoke prevention. I have found out that between the years 1856 and 1872 there were 167 patented smoke-preventing devices in Great Britain alone, nearly every one of them being guaranteed to do what is claimed, that is, to prevent smoke with the help of a good engineer and fireman. That was never neglected.

I find that all recent inventions for smoke prevention have been modifications of those inventions that have gone before. Anyone who is familiar with Holly's "Locomotive Engineering" or Clark's "Railway Machinery," can find out everything relating to smoke prevention that is likely to be known to-day. There is no question but that they prevented smoke fairly, not very well, not entirely. My experience in the British Isles and on the continent of Europe is that the smoke that rose from the trains is just about as bad as it is on the lighter worked lines in this country. They have come to acknowledge that a certain amount of smoke is necessary. If it is very bad they get after the enginemen. I think that the locomotive departments in this country will have to settle down to the same thing, not forgetting to keep after the men who cause a nuisance from smoke.

I might say that among the great number of patented devices that were brought out in Great Britain none of them is in use today except the brick arch, which, by the way, was not a patented invention. The brick arch was first applied by Mr. Briggs of the Boston & Providence Railroad and it was adopted very promptly in Europe, and was the most successful device in smoke prevention.

Mr. J. H. Setchel: Mr. President, it seems to me that the remedy for black smoke is a good deal like the remedy for many of the ills that human flesh is heir to, and the remedies always prescribed by the doctors. " Rest, perfect quiet for about a week, do not eat too much, and I think you will be all right." When we have to cure the black smoke evil, we refer directly to the engineer and fireman. I think they are fully as important a factor in the matter as is the doctor when he prescribes rest, and it emphasizes more clearly than anything has what my friend Gaines and two or three other speakers have referred to, the necessity of a mechanical stoker. Regularity in the operation of the locomotive ensures the absence of smoke almost absolutely.

I remember a number of years ago that the lamented M. N. Forney in speaking in this convention said that he would guarantee that if you painted a smoke stack sky blue it would prevent smoke as long as you could get the engineer and fireman to give special attention to the matter [Laughter.] I believe that is true. As soon as the engineer and fireman cease to be interested in preventing smoke then we are sure to have smoke, and it seems to me that the only remedy is a mechanical stoker, and then I am not sure but we will need a mechanical man to attend the stoker. That will be the only way to prevent smoke. I notice what has been referred to by one of the speakers, that some eastern road has suddenly discovered that there is a remedy for black smoke, and that is the engineers and firemen, and that they propose to give special attention to it hereafter. If they will only continue to do that I think they will be all right.

Mr. Curtis: Mr. President, I do not want to discourage anybody about the mechanical stoker preventing smoke, but I believe that the mechanical stokers for stationary service are perfected to a reasonable degree, and a great many of them do not make much smoke. But if you do to those mechanical stokers what you do to the locomotive, it will make smoke, and that is what is called overcrowding it. I think a great many mechanical men in this room have often selected an engineer and fireman to take the Board of Directors over the road and did not have any smoke that day. The reason was that the engineer and fireman were very careful, or on their mettle, that day.

Also the engine was put to very light duty. Had that Board of Directors' train been coupled up to fourteen or fifteen sleepers you would have seen smoke from the engine. I do not know of any way in which we can do so much work in a small fire box within the limitations that we get upon a standard gauge railroad and with the high capacity locomotive, without having smoke at the smoke stack when we are doing what we can in the production of power in proportion to the size of the plant.

THE PRESIDENT: Is there anything further on this subject, gentlemen? If not, we will proceed to the next subject. The next subject is "Alloy Steel: Results from Use in Machine Tools and Special Cutters." Mr. J. A. Carney being absent, the Secretary will read his paper.

TOPICAL DISCUSSION — ALLOY STEEL.

MR. J. A. CARNEY (C. B. & Q. Ry.): Alloy steel is commonly known as "high-speed" steel. Some five years ago a specification was made for certain lathes which gave the general dimensions of swing and length between centers and stipulated that they should cut 50 feet per minute with ⅛-inch feed and ¼-inch depth of cut in medium steel. These specifications were submitted to machine tool makers and without exception came the reply that such tools were not made. To-day tools are turned out whose principal selling point is the fact that they will more than do the work specified five years ago. So much for the improvements in machine tools brought about by the introduction of alloy steel.

The ability to take heavy cuts at three to four times the speed used with tempering steel is an item of great merit, but to my mind the most valuable feature is the steel's ability to continue at work almost indefinitely without losing its cutting edge. The time taken removing tools which have lost their cutting edge and replacing them with dressed tools is dead loss; it curtails output and prevents maximum efficiency of a machine and is a source of annoyance to the machine operator.

Compared with tempering steel one-fourth of the number of tools of alloy steel are a more than ample stock because of their ability to stand up to the work. In one case 250 pounds of tem-

pering steel was replaced with six pounds of alloy steel. The money spent on dressing tools is probably not one-tenth of what it would be if a similar output were undertaken with tempering steel.

The high cost has made it unprofitable to use alloy steel for heavy milling tools, reamers, cutters, etc.; and it is very generally the practice to use teeth of alloy steel inserted in a body of a material much cheaper and less liable to fracture. The results are good, a more even and efficient temper can be obtained on a small piece than on a large and bulky one, and there is no danger of spoiling the body. The milling cutter with inserted alloy steel teeth has brought the slab milling machine to its present state of high efficiency and on many operations it is more efficient than a planer.

Drills and reamers with special alloy steel inserted cutters have revolutionized many methods of finishing engine parts. Steel bushings 2½ inches and 3 inches in diameter bored from a solid rod can be made cheaper than by any other process. Cored steel castings that were formerly bored out on a lathe or boring mill can be reamed out on a drill press with a special cutter for one-fourth of the former cost. One reamer with alloy-steel cutters will ream a hole increasing the diameter ½ inch in one cut where four cuts are necessary with tempering steel. In a shop which formerly spent $75 a month on repairs to reamers the cost has been reduced to less than $5 with high-speed reamers.

It is needless to go into a long list of detailed operations; they are to be found in every shop, and if we are a little slow catching on, some of our good friends in the machine-tool line will show us the error of our ways.

One of the most noticeable improvements on some classes of machines is the method of fastening the work, brought about entirely by the use of alloy steel. This is particularly true on the new designs of driving-wheel tire lathes.

Alloy steel is particularly valuable in finishing brass, and a speed of from 200 to 375 feet a minute can be maintained. Sand in the casting does not so seriously affect the cutting edge as in tempering steel. These results are impossible with tempering steel.

The use of high-speed steel for track work is of immense value. There is no shop or tool dresser with a section gang, and the failure of a drill may mean the loss of a day's work. In a recent test on track drills a special make of tempered steel drilled 47 holes, 15-16-inch diameter, 5/8-inch deep, and had to be redressed. A high-speed steel drill at the same speed and feed drilled 308 holes and was in good condition.

Flue-beading tools, rivet sets, air-hammer chisels, etc., made of alloy steel do so much more work than tools made of tempered steel that they are an economical proposition. Rivet sets should not be tempered. The heat of the rivet does the tempering.

Plates of alloy steel have been successfully brazed to pieces of common soft steel and used for finishing tools on tire turning.

It would be almost impossible to tabulate the improvements made and the costs reduced by alloy steel, but it can be summed up as follows: First, Heavier cuts at faster speed; second, Heavier and more powerful machine tools; third, Improved methods of fastening work; fourth, Use of inserted tooth cutters in place of single tools; fifth, It is difficult to say how much a reduction in cost of machine work can be attributed to alloy steel, but this fact is apparent: An increase in machinists' wages of about 35 per cent in the past six or seven years has not increased the labor cost of machine work and in many cases the cost has been lessened by the use of alloy steel and machines designed for its use.

First Vice-President H. H. Vaughan in the chair.

THE CHAIRMAN: Gentlemen, this paper is now open for discussion. Mr. Henderson, can we hear from you on the subject?

MR. GEO. R. HENDERSON: I do not think I have anything special to say on this subject, Mr. Chairman. The only thing I might say is that the particular point in connection with the tool steel, as brought out in this paper, is the enormous increase in the size and capacity of the machines. My attention was called to that two months ago by a test which was made by William Sellers & Co., of a couple of wheel lathes which they had built for the M. K. & T. Railway. There were a number of new principles involved and brought out in connection with the use

of this steel, and whereas it used to require a few years ago ten hours or one day to turn a pair of tires, in this test three pairs of tires were turned up in one hour, which is a pretty good showing. Of course, this was a combination of high-speed steel and very heavy machine built for the purpose of getting all there was out of it.

President McIntosh in the chair.

THE PRESIDENT: Gentlemen, this is a very important subject and I hope that all of you who are familiar with it will take part in the discussion. You have all seen more or less of the very excellent exhibit of machine tools in this pavilion and the wonderful work that they are doing.

MR. GAINES: Recently I have had a chance to try a little, although not as much as I would like to, some high-speed steel with vanadium content. The tools I tried were in connection with pneumatic tools, caulking, chipping chisels, things of that sort. It is simply wonderful the punishment you can put that steel through for that purpose. I am going, later, to experiment with it in machine tools to see if I can get as good results. I would like to hear if anyone has tried the high-speed steel with the vanadium content in it.

MR. VAUGHAN: The use of alloy steel, Mr. President, has practically made a revolution in our machine-shop practice in the last few years. That is a fact which I think no one will deny. Most of us will probably remember the convention of 1901 when the representatives of the Bethlehem Steel Company were exhibiting samples of chips that none of us had ever seen before. Since that the use of alloy steels has progressed until to-day they are, I suppose, used in practically every railroad shop as well as other manufacturing establishments. In getting records to-day of what can be done it is more a question of the class of machinery that our shops are equipped with than of the composition of the steel. Our experience has generally been that it is necessary to use a certain amount of caution against too much crowding with these high-speed steels. We are liable to waste more money tearing tools to pieces of the older type than the increased output pays for. Perhaps from one point of

view it would be better to tear them to pieces and replace them with others, but it is not always easy to get money from the management to replace tools that are only a few years old and which will give us pretty good service. In our selection of high-speed steel we have found it advantageous to pay a good deal of attention to the strength of the steel. There appears to be a variation between the compositions of the steels offered by the various makers, although a majority of them seem to me to give fairly reasonable results. It is also difficult to choose between one steel and another on tests, but we do find that some steels are very much more friable than others, and it is rather a hard thing to clean up a dollar's worth of high-speed steel in a cut just because you are using a brittle steel. We found considerable advantage from making a series of tests, taking a number of different makes of high-speed steels and selecting those which appeared to break the least or to be liable to fracture the least. Another thing which we have done, which I think is a good plan, is to limit the number of high-speed steels we use to a certain quantity. Our standard is to use only three steels, and while we have, of course, had a good deal of difficulty in keeping down to that, we have done so for the last year or two simply to have everybody familiar with the standard grades of steel, and not handle ten or fifteen different kinds of tool steel through the tempering room. I would certainly concur with Mr. Carney as to the wonderful wear that these steels give us when properly handled and taken care of. Our wear with high-speed steel is very small, considerably less than it used to be, I believe, with carbon tool steel in the older days, and on drills, not only one but several makes of high-speed drills, we have found we could drill about a thousand feet of metal per inch of drill, which is certainly a wonderful record for a material that will drill at the speed which the high-speed steel does. I feel that the steel people almost can take a rest at the present time. It is up to our equipment to catch up with the steels in many cases. Those of us who have the most modern tools can make good use of them; but in the older tools we are running up to the capacity of the tool, and it means a large expense in the future in tools and machinery to keep up with the present advance in alloy steel.

Mr. C. D. Young (Penna. Lines): In answer to Mr. Gaines' question as to high-speed steel that is in use with vanadium, I might say that about a year and a half ago we started to try vanadium high-speed steel and got excellent results from it. I think the steel that we got contained about .30 of vanadium, about .7 of chromium and about .18 of tungsten. So in this combination vanadium is the prevailing alloy. This steel is cited in Mr. Taylor's paper read before the American Society of Mechanical Engineers in December, 1907, in which paper, I think, Mr. Taylor thoroughly covered the high-speed steel question up to the time of his paper. We have been using this alloy steel on cast iron, manganese steel, on high carbon steel and some on brass; but not on bronze, as it has not given good service on this metal. We have been able to turn out thirteen pairs of truck wheels with vanadium tools without regrinding, and have averaged about eleven pairs of wheels per tool. These wheels were turned out on a 36-inch truck wheel lathe at an average time of turning of about 40 minutes. Therefore, it may be said that tools with vanadium content have given very good service.

The President: Gentlemen, the question was raised as to the extent to which vanadium had been used in tool steel. I can only tell you about one chisel, that is, from actual experience. We had some trouble with transmission bars on a certain class of engine, and decided to order some with vanadium steel. They came along in due time and did very well. We decided further that we would have another set forged from vanadium steel. Those came, too, and we started in to machine them. Well, I guess they are busy at it yet in our shops. [Laughter.] They finally, in experimenting, took out a piece and made some excellent cold chisels from the vanadium steel. We took the matter up with the vanadium people and it was finally traced until they discovered that what they intended for tires was used for transmission bars. I can safely say that if that is the quality of steel they are furnishing for tires we can expect extraordinary wear from them in that line of service.

Mr. R. P. C. Sanderson (Virginian): Mr. President, one point in connection with this matter of high-speed steels in modern machine-shop practice has been referred to only indi-

rectly, and that is the system or shop methods of using it. To illustrate the point I wish to make, I will say that when the Taylor-White process steel was first exploited in this country at the time Mr. Vaughan referred to, I visited the Bethlehem Steel Works with the view of going into the matter personally to see whether it would pay the company I was then working for to buy the rights and use it. They gave me every facility for going through the shop. I found that they had gone to work in the most thorough manner and figured up the actual capacity of every machine they had. They had calculated the strength of the spindles and arrived at the strength of their lathes and tool holders, and so on, the strength of the gears that drove the machines, and they decided just what pressure could be borne at the point of the tool without paralyzing the machine. In some cases they had gone so far as to break the machines down to establish that pressure. Having done that they went through a careful series of experiments to show the power required to tear off the metal with properly formed tools at given speeds, depths of cut and feeds in different qualities of steel, nickel steel, high carbon and low-carbon steel and wrought iron. Having done that, they tabulated the work that should be done and speeds that should be used for the different feeds and cuts of each machine in their shop. Then they did not leave it optional with the men at all as to how they should turn out the work, but they had speed bosses around the shop who checked up the speeds actually used by the mechanics, and they followed it up so closely that they practically got the maximum possible output from each machine of each type. That was done in that shop, and I made up my mind that a large portion of the great advance they had made in machine-shop practice was due to their thorough method of enforcing the maximum output of every machine and every man rather than the mere ability of the tool steel to stand the work; and we can not get the results that we should unless the same pains are taken by the machine shop foremen and management to force the output of each machine up to the full capacity both of the machine and the tool steel. One thing won't bring results without the other.

MR. DEVOY: Mr. President, much of this discussion seems to

resolve itself into the amount of work that can be gotten out of a lathe or a machine of that kind, and particularly with reference to the repair of steel wear. I would like to mention one thing that to me appears more important than the getting out of the work. That is, that in turning a pair of drivers, tires of drivers, or a steel-tired wheel, I have in many cases, and on more than one railroad, seen the operator pay absolutely no attention to what the size of his wheel was to be turned. To make myself more clear, I would much rather lose 10 or 15 or possibly 20 per cent in the amount of work done, and on every pair of wheels see the witness mark, or a small portion of that tire that had not been turned away. I would prefer to have the last sixteenth of an inch in a tire for additional wear than to see a man rip the tire to pieces in say seven or eight revolutions on a driving-wheel lathe. You will save much more money in the long run if you attempt to make your operator observe that point, and if he will, in turning the wheel each time, try to observe that, I believe you will save more than you will by any increased output.

Another point came to me very clearly in looking to the reason why we have cracked tires, especially in the winter time. It appeared to me that, in turning the tires, possibly the tool, notwithstanding the great power of the lathe had, so to speak, laminated the steel, and that there was a slight fracture there. If any of you have examined tires as they first begin to break, especially in a cold country, you will see a slight crack on the outer edge of the flange of the tire, and following that up further with a microscopical examination it has appeared to me that a great deal of that has been caused in the driving-wheel lathe; that it has been the great power exerted that caused the fracture of the steel tire. I am not at all opposed to a powerful machine; the more power it has the better, and I believe the Milwaukee Road was one of the first in the country to adopt the 100-inch wheel lathe, one of the largest — I am not opposed to that at all, but I do particularly want to call attention to the necessity of seeing that every operator should leave that witness mark on his steel tire, not to the detriment of the proper rolling of the wheel, but just to show that he has not wasted that sixteenth of an inch in tire wear.

rectly, and that is the system or shop methods of using it. To illustrate the point I wish to make, I will say that when the Taylor-White process steel was first exploited in this country at the time Mr. Vaughan referred to, I visited the Bethlehem Steel Works with the view of going into the matter personally to see whether it would pay the company I was then working for to buy the rights and use it. They gave me every facility for going through the shop. I found that they had gone to work in the most thorough manner and figured up the actual capacity of every machine they had. They had calculated the strength of the spindles and arrived at the strength of their lathes and tool holders, and so on, the strength of the gears that drove the machines, and they decided just what pressure could be borne at the point of the tool without paralyzing the machine. In some cases they had gone so far as to break the machines down to establish that pressure. Having done that they went through a careful series of experiments to show the power required to tear off the metal with properly formed tools at given speeds, depths of cut and feeds in different qualities of steel, nickel steel, high carbon and low-carbon steel and wrought iron. Having done that, they tabulated the work that should be done and speeds that should be used for the different feeds and cuts of each machine in their shop. Then they did not leave it optional with the men at all as to how they should turn out the work, but they had speed bosses around the shop who checked up the speeds actually used by the mechanics, and they followed it up so closely that they practically got the maximum possible output from each machine of each type. That was done in that shop, and I made up my mind that a large portion of the great advance they had made in machine-shop practice was due to their thorough method of enforcing the maximum output of every machine and every man rather than the mere ability of the tool steel to stand the work; and we can not get the results that we should unless the same pains are taken by the machine shop foremen and management to force the output of each machine up to the full capacity both of the machine and the tool steel. One thing won't bring results without the other.

Mr. DeVoy: Mr. President, much of this discussion seems to

Carney's paper where he referred to the fact that the increase in the output due to high-speed steel had about offset the increase in wages, and that has suggested to me a comparison of the efficiency of the machine tools, the efficiency of the men and the wages paid. When I was at Mr. Carney's shop recently, he pointed out to me a machinist who was earning nearly $200 a month on piece work. I remember the time when the Master Mechanic of the Altoona shops was not paid half that money, and it occurred to me that there is a possibility of the machinist getting a greater proportional benefit from the use of high-speed tools than the railroads get. One speaker just reported fifteen pairs of tires turned with one grinding of the cutting tool. It must have been a powerful boring mill that the company had bought at a big expense, and there was high-speed steel which they had bought at a high price, and the machinist only had to turn that tool once for fifteen tires, and he was paid a good price per piece. The thought I wanted to suggest is that the cost of repairs of locomotives, even on a basis of the increased weight, has not been reduced very much, and yet if we were to get the maximum benefit from the money the railroads have expended for putting in heavy machine tools, electric motors, high-speed steel and all those things that are so efficient, and do so much more work than the old style work, why don't we show a much larger reduction in cost of repairs. Although I am in favor of a machinist earning fair day's wage, possibly in many cases, under piece work or premium systems, he is being very much overpaid, and that the reason it is permitted is because we are getting such an enormous efficiency out of these improved conditions. The machinists' union appears to have so much influence that a larger proportional benefit from the use of improved appliances and tools goes to the workman than to railroad stockholders who provide the capital which provides for the improvements.

MR. CURTIS: I listened to what was said about the cracking of tires, owing to the high duty steel. I want to ask if climatic conditions do not enter into that. The Louisville & Nashville R. R. was the first road to use the heavy wheel lathes. We take all there is to come off in the first cut and finish it in the second.

If a tire is worn deeply it doesn't make any difference. We have averaged about 800 locomotives in service for the last four years and we have not broken a tire. I do not see what the tire lathe has to do with the tire in the breaking of it. On the other hand, in turning M. C. B. 5 by 9 axles and 5½ by 10-inch axles in double-headed axle lathes, I have seen the axle spring in the middle on the first cut in taking off the stock. It is finished on the second cut by a light cut. We have never had one of those axles break, nor to run hot through the journal being out of true or damaged by the use of high-duty tool steel. I have been watching that very closely. I only bring this up as a citation to meet what has been said about the improved work done by high-duty steel.

MR. GAINES: I want to confirm what Mr. Curtis has just said. I do not believe that the rapid work has anything to do with the development of flaws in the tires. I know one road that has been turning out their steel-tired passenger coach wheels with a roughing cut, omitting entirely the use of the scraper. We find that these wheels, after five miles use, are perfectly smooth.

Referring to what Mr. Forsyth had to say in regard to the company getting the benefit of the cost, I believe we are going to get that benefit. We are getting it now some, and I think we are going to get it more as we get into the use of the handling of high-speed steel. I have recently installed one of those 42-inch heavy-duty steel-tired wheel lathes. We used to get out two pair of wheels or two and a half a day with an old machine. We don't employ a regular machinist. We use what we call a handy man and we are getting out our wheels for about twenty cents a pair where we used to pay anywhere from 80 cents to a dollar.

MR. DEVOY: So far as my observation is concerned, climatic conditions absolutely govern all tire failures. I have said many a time when it was thought that there would be some danger of any tire failure that I would give more for one week of good weather than for anything else. As soon as the good weather comes, you are absolutely through with your tire failures. I would like to ask the gentleman in the South if he ever had a

tire failure, because I do not see how they could down in that section. I would like to ask the gentleman if he has ever paid any particular attention to the breaking of wheels and as to whether he has made any figures as to that sixteenth of an inch he has saved that company in tire wear. It will pay him. I do not object in the slightest to the amount of work a man will do; but there is a point in which he can save money by not turning off the steel. I would like to ask another question. If any of the gentlemen have had any tire failures, have they ever taken the pains to find out whether there were any cracks, or whatever you want to designate them, in the flange of the wheel; because invariably they do occur, and in taking it up with the steel people I have never heard them offer any remedy for that crack, and if you will follow it in the driving wheel, it is started there.

MR. VAUGHAN: I would like to say in regard to this cracking that we have had several cases of slight cracking in the flange and on engines that have not had any turning except the first turning at the works. I will not oppose the idea that a heavy turning of the flange might start little cracks, but I think that is fairly good proof that this class of failure can occur from other causes. I am inclined to the idea that this damage couldn't occur if the tire were perfect. If there is any defect in the tire, a heavy cut might disturb the metal and start a crack. I believe these cracks that start through the flange are entirely due to the bending of the flange. There is no question at all in my mind that climatic conditions have everything to do with it. All our tire troubles come in the winter time. As soon as the frost gets out of the track we do not have any tire troubles until the next winter, but one of the troubles we have experienced with the very best grades of tire we can get, is a little crack starting through the top of the flange, and I believe it is due to the bending backward and forward of the flange. I think tire troubles have increased under severe conditions; and while we are using a very much stiffer center than most people, we have still a little of it.

MR. CURTIS: I think I should answer the gentleman who asks if we have inspected our wheels. Our wheels are all

inspected carefully and we leave a little black spot as a general rule on one of the wheels — not turning off any more than necessary — and the wheels are all properly mated, workmanship first-class. The gentleman asks if we ever break a tire. I recall the breaking of a tire on a 68-inch wheel on a hot summer day. The tire was 1½ inches thick, and the engine had 16 by 24-inch cylinders. The tire had been run too long and it broke from the inside outward. That is the only one I recall in the last five years, and that was before we started to use the heavy duty tool steel.

THE PRESIDENT: Gentlemen — I think a good deal of attention should be given to what Mr. Vaughan has said in regard to the springing of the tire and wheel causing these flange cracks; it is possible it is sometimes caused by unequal shimming of the tires in setting them. For instance, if you do not shim the entire circumference of the wheel there are apt to be spaces left where springing will occur. I will ask Mr. Chambers, our Master Mechanic, if we have not encountered some broken tires?

MR. C. E. CHAMBERS (C. R. R. of N. J.): As to the matter of broken tires, would say we have found and removed several cracked tires before failure, that apparently started through flange; I am not, however, of the opinion that the breakage or cracks occurred through misuse of tool in tire turning lathe in the shop. If this was truly the case it might occur on all classes of wheels. As my memory serves me, it only occurred on wheels of outside diameter of 69 inches or upward, and I think the breakage is largely caused by springing of cast-steel wheel centers. I think the practice in the past has been to use cast-steel wheel centers of too light proportion, and that increasing the stiffness of the wheel most of these troubles will be cut out.

MR. D. J. REDDING (P. & L. E. R. R.): The introduction of high-speed steel started the practice of making records on boring mills. You will seldom find a full set of driving-wheel centers which will all caliper alike. Where you bore them in such a hurry, and necessarily try to bore them to one size, somebody has got to shim them when they are put on, and I think as many of them are broken from improper shimming as from any other cause. The men who put on tires are not expert mechanics and

do not realize the necessity of working to a 60th or an 80th of an inch, as our gauge calls for. The majority of men, in boring tires, do not know anything about an 80th. They use a rule marked in 16ths. I am inclined to think that a little less speed and more accuracy in boring might very often prevent the breaking of tires.

MR. A. LOVELL: The question has been raised here as to whether the full benefits of high-speed steel were being realized or whether the benefits derived from the high-speed steel were not being used up by the extra cost of machine tools, and in paying additional wages to the men operating them. I think that is a matter which will work itself out in time, to the benefit of the railroad. I think possibly as yet it is not fully adjusted and it is a very important matter.

When new and improved machines are introduced into any shop where piece-work rates, or any premium system is adopted, it is very essential that the piece-work rate shall be adjusted to fit this new condition of things. The old rate should not then prevail. Again, it is very important that care should be exercised in providing new and improved machines to get the greatest benefit from the high-speed steel, that these machines be only introduced in such places where their full benefit can be utilized. For instance, if we have in a large machine shop, an old driving-wheel lathe which will stand the work at a slow rate of speed, and perhaps valued at $2,000, it would be good economy, if a new tool could be utilized all the time, to pay $10,000 for a high-speed extra heavy machine in which the tires might be turned at the speed which has been represented here,— three pairs in an hour. On the other hand, if this $2,000 machine is located in a small shop where there are only a few tires to be turned, and the machine is not in operation more than half or one-third of the time, it would not be good economy to throw away that machine, and expend $10,000 to buy one of the high-speed machines. It would be better economy to pay for a little more time to the workman and do a little less work.

I think these matters should be looked into very carefully, and eventually the full benefits of the improved steel will result to the benefit of the railroads.

The President: If there is no further discussion on this subject, we will take the next one, the report of the committee on Washing Out and Refilling Locomotive Boilers, Mr. H. T. Bentley is the chairman of the committee.

Mr. Bentley read the report.

REPORT OF COMMITTEE ON BEST SYSTEM OF WASHING OUT AND REFILLING LOCOMOTIVE BOILERS, INCLUDING BLOW-OFF LINES, FLUSHING TANKS, HOT WELLS, AND OTHER SIMILAR METHODS, AND DATA PERTAINING TO BENEFITS IN THE WAY OF REDUCING DEFECTS IN FIRE BOX SHEETS, STAY BOLTS AND TUBES.

To the President and Members of the Master Mechanics' Association:

The wording of the subject assigned to this committee asked particularly for data pertaining to benefits in the way of reducing defects in firebox sheets, stay bolts and tubes, but as this is only a small part of the many benefits derived from washing out with hot water, we have felt at liberty to go into the matter more fully in other directions, as the actual data obtainable about reduction in stay-bolt breakages, leaking fire boxes and flues, from the use of hot water, was very meager.

The best system of washing out is one that will do the work properly, with the least change in temperature in boiler, at a minimum expenditure of heat, and in the shortest possible time.

To say which system is the best for obtaining the above results is not within the province of this committee, but as there are several on the market which will do what is required of them, and each of them, so far as we can find out, is giving satisfaction, no particular make will be mentioned.

The fact that good results are obtained by having less trouble from fire-box and flue leakage, and a reduction in the number of stay-bolt breakages, and last, but not least, the reduction in terminal delays, would appear to warrant the expense of installation.

The more nearly uniform the temperature is kept, the less expansion and contraction takes place, especially in the fire box, which must reduce the vibration in stay bolts and give them a correspondingly increased life.

It has been demonstrated beyond a doubt that when a boiler is kept at a uniform temperature, the least trouble is experienced in the matter of leaking flues and fire boxes.

Under good water and coal conditions, fires are seldom dumped and leaks are almost unknown. Most of this, of course, is due to the water, but most of us have known of engines that have given trouble account of leaking every day; when placed in the hands of certain engineers, would run day in and day out for a long time and be absolutely dry, the secret

of the man's success being in the uniform temperature maintained, by insisting on careful firing, proper handling of dampers, and a scientific use of the injector. If such a condition can be obtained, and we know it is possible, it speaks volumes for maintaining the same temperature as far as possible in fire box and boiler; yet, how many are there of us who, when an engine is coming in from a run, will stand by and see all sorts of things done that, in our thinking moments, we know to be absolutely wrong. We apply cold water through the injector, while no circulation is taking place in boiler, we then blow the steam off by letting it escape to the atmosphere, after which the blow-off cock is opened, and a boilerful of hot water runs down the sewer; and then, as if not satisfied with wasting such a large amount of heat that we will have to replace later on at a cost of probably 800 to 1,000 pounds of coal, we turn on a stream of cold water and go through the washing-out process, so that the fire box is at a temperature of 45 to 50 degrees, and the top of boiler and some of the upper flues are still hot. Then is the time that some boilermakers get their work in; and we are surprised to have someone tell us that a report like a cannon was heard in the fire box and a crack developed in side sheet that has put our engine out of commission for a time, or if we are fortunate enough to miss the cracked side sheet, we fill our boiler up with cold water and reverse the process that has just taken place; a large fire is put in the box and blower applied, so that we have steam on, before the water around mud ring is hot, and often after the engine has gone a short distance on the road we get word from the train dispatcher that the fruits of our abuse has shown itself in a dead locomotive that is blocking traffic. This is not an exaggerated picture, but fortunately it is getting to be understood that this condition can be improved at a reasonable cost.

In taking the question up with a number of Superintendents of Motive Power, who are using various devices having the object of washing out, changing water and raising steam quickly, by the use of hot water, and live steam where necessary, the following information was gathered:

1. That there are four or five different systems in use.
2. Have been in use from one to three years.
3. Cost from $5,500 to $20,000, depending on size and number of stalls equipped, or at 5 per cent interest would mean an expense of from $275 to $1,000 per year.
4. In the various systems reported, statement is made that they are entirely satisfactory.
5. Can wash out and get ready for service twenty to twenty-six engines per twenty-four hours.
6. Average time of the various roads reporting, to wash out and get engines ready for service, varied from 55⅓ minutes, on one road, to 4 hours 15 minutes, on another.
7. Average time formerly taken, 3 to 6 hours.
8. Practically no change or improvement made since installed, one user saying that in his system would suggest a settling well, so that water

blown out of boiler might be utilized again after the mud and scale had been deposited.

9. In all cases a very marked reduction was reported in flue leakages and broken stay bolts, although very little data were available on this subject. At one point it had been possible to reduce the number of boiler-makers employed from ten to four, due to decreased boiler work, since the hot water washing-out system has been installed.

10. Some of the other benefits derived are given as follows: No evidence of steam in roundhouse. Always plenty of water (hot) to refill boilers at 212 degrees. Temperature of water reduces time and fuel necessary to get engine hot. Facility in turning engines, reduction of engine failures, reducing overtime. Reduction of time at terminals where washing out is necessary.

Probably the most important saving that is effected by the hot water changing or wash-out system, is the rapidity with which the work can be done, and thus get engines into service from one to two hours quicker than could possibly be the case with a cold-water system, which necessitates cooling an engine down after the steam has been blown off, before the engine can be washed out, and then directly after bringing the water back to the original temperature that it was when engine came in off the clinker pit; such waste of heat, which means coal, would not be tolerated under any other conditions, but takes place daily at hundreds of roundhouses in this country, without any protest from the people causing this waste.

A simple arrangement used on one of the Western roads with very great success, for utilizing steam and water otherwise wasted, is to have wells into which cold water flows from the main, or source of supply, and to heat it, steam and hot water from engines is blown off into well; from this place the water is pumped for washing out and filling boilers. This is probably the cheapest system for furnishing hot water, but it has the objection that you are using water that has been blown from dirty boilers; but as only a boilerful is taken, it is soon diluted and rendered innocuous by the fresh water injected into it from the tank.

The following actual savings have been reported:

Decreased cost of washing boilers; in 1906 with cold water, for labor alone it cost $1.32 per boiler, whereas, with hot water in 1907, $1.01 was charged against this item, or on the road reporting it, a saving of $2,019.95 per year for labor alone, in washing boilers, was effected on an outlay of $6,000.

Decreased cost of water used. This item may not appear at first sight to amount to much, but where a saving of 7,000 gallons for each boiler washed out can be effected, as has been reported, this, at 7 cents per thousand gallons, in Chicago, amounts to 49 cents per boiler washed. It is the opinion of your committee, however, that this estimate of the amount of water saved is high.

Decreased amount of coal used. On one road this is given at 140 pounds per engine, which is probably low; this at $2 per ton would amount

to 14 cents, so that with the three items mentioned we get a saving per engine of:

Labor	$0.31
Water	.49
Coal	.14
Total	$0.94

The saving of time at the roundhouse is probably, in busy seasons, more of an object than anything else we have mentioned, and as this amounts to cutting the time in half for washing out, it means, assuming that engine is not held for any other work, that with 1,000 engines, each turned two hours quicker than was possible with the cold-water system, you have a saving of 2,000 engine hours, and as engines generally have to be washed out once a week, or four times a month, in bad-water territory, it amounts to 8,000 engine hours a month, or 96,000 engine hours a year; this, if the engines have to be rented at $10 a day, which is a low figure for a large engine, in busy seasons, would cost $40,000; or, putting it another way, working 365 days of 12 hours each, it would require practically 22 additional engines to equal the 96,000 engine hours a year, which, at $15,000 per engine, would mean an expenditure of $330,000.

In conclusion, your committee recommends that boilers be washed out and filled with hot water, and that the savings obtained by doing so will pay a good interest on the necessary investment.

H. T. Bentley, Chairman,
L. H. Turner,
S. K. Dickerson,
M. E. Wells,
H. E. Passmore,
Committee.

Mr. Bentley: Since writing this report I have had opportunities of seeing in operation hot-water wash-out plants that actually do in a very satisfactory manner all that the most sanguine would expect.

At one place I found the steam and hot water being utilized to heat two tanks, one at a temperature of 140 degrees for washing out and the other at from 175 to 200 degrees for filling up, and there appeared to be plenty of hot water at above temperatures to meet all the requirements.

In figuring on the actual saving in time, coal and water, would say, that the amounts given by your committee are probably under, instead of above, the mark and would revise these figures as follows:

Labor	$ .30
Water, at 7 cents per M..........................	.14
Coal, at $2 per ton................................	1.00
Total, per engine	$1.44

Just at present, owing to the business depression, we are not crowded for power, but in busy times anything that will enable us to turn an engine out in one-half the time, after being washed, is worth considering.

One thing that impressed me in connection with the filling up of boilers was the large-sized pumps used, which made it possible to fill a large locomotive boiler in nine minutes, where the best we do is about twenty minutes.

A larger blow-off pipe than 1½ inches as used on most roads is very necessary for quickly emptying and filling boilers.

The reduced amount of boiler work necessary is evidenced by the number of men laid off at several places investigated since the introduction of hot-water washing out. The men handling the hose can do so without inconvenience, where the temperature does not exceed 140 degrees, but in filling up, where the water is as high as 200 degrees, it is not necessary to handle the hose, and therefore no trouble is experienced.

The savings from coal, water and labor alone will pay a handsome interest on the cost of installation, and I have no hesitation in recommending this system, where economical results are desired.

THE PRESIDENT: This subject is now before you for discussion.

MR. HENDERSON: I am very much interested in the last portion of Mr. Bentley's discussion regarding the plant which he recently inspected, and I think it would be interesting if he would give us more of the details. There are several things that would be of interest. He states there were three tanks in which water was held at different temperatures. I suppose there was a line of pipe to run the water from the blow-off tank, and another line for washing out. Is there not another pipe for the higher temperature water? If Mr. Bentley will give us a little of the details of what the lines were in this connection, it would be very

originally in the cold-water method. It was found in doing this that there was not very much saving in time by the hot-water method. The difference in cooling down from 350 degrees to 110 or 120 degrees, which is about as hot as one can wash out, is not very different from cooling down from 350 degrees to 60 or 70 degrees, so that the time actually saved in washing out by that method was not very great.

We then adopted the method which Mr. Vaughan speaks of, of drawing off the water, and immediately washing out with hot water, as hot as the workmen could handle in the hose, about 130 degrees. That method has worked satisfactorily, and as far as I know, there has never been a cracked sheet; up to six months ago there had not been one and the system had been in use about a year. This method of washing was contrary to my ideas of what would be best for the boiler sheets, but was adopted as a standard to get the best results, or greatest saving, by the hot-water washing-out system.

This system was so arranged that the steam was blown off through some brass tubes, in some heating tanks, which heated the water for filling up the boilers. Any surplus steam went to a settling tank under ground, into which the water from the boilers was run out through an underground pipe, after the steam had been blown off. The steam was blown off through these heating tanks first, and the water drawn off through the pits, and run into the settling tank under ground. The washing-out water was pumped back out of the settling tank to wash out the boilers. That was found to be as hot as the workmen could use it, and it was necessary at times to use cold water with it to temper it down. After a boiler was washed with this waste water, fresh water was taken from the heating tanks, through which the steam had passed, with which to fill the boiler.

I think by the old method of washing out, it took from 7 to 10 hours to cool a boiler down, wash it out, fire it up and get steam enough to get it out of the roundhouse. Under the new arrangement, I think it takes 2 hours and 50 minutes to do the same work; possibly 3 hours, or something in that neighborhood.

Mr. Wildin: In the locality where I am at present we wash

engine out quickly. No matter what reason you may have for taking out the water, whether you only wash your boiler once a week, or once in many weeks, depending on the water, it is oftentimes necessary to empty the boiler for other purposes, such as leaking flues, boiler mountings and other defects.

Where you have a system installed primarily to wash boilers, you can figure much closer and know, no matter what work you have to do on the boiler, if you can get it done within thirty minutes of the time the engine is required you can get your engine heated up in good season. If you use cold water you have to allow more time.

MR. BENTLEY: Mr. Passmore, one of the members of our committee, has some information which I have no doubt he will be glad to give to the members.

MR. H. E. PASSMORE (T. & O. C. Ry.): It is rather unkind on the part of Mr. Bentley to call upon me in this way, but I happen to be slightly familiar with the system which was talked about.

As I understand the system, and as we looked into it, the two tanks have in connection with them, two pumps, one being used for washing-out purposes and the other for filling purposes, and there is a system of pipes and valves which make it convenient to blow out, wash out and fill up any number of engines you want according to the size of the tank. You can put in a tank large enough to take care of one or half a dozen pits. It is just a detail of the piping, etc.

THE PRESIDENT: I would like to hear from Mr. Manning. He used to say something about washing out boilers when he was on the Union Pacific, and I do not know whether he has forgotten about it or not.

MR. MANNING: I have not forgotten my former experiences, Mr. President, but on the railroads with which I am now connected, washing out boilers is not as important as it was on the Union Pacific. We do not have to do it quite as often, and we would not do it as often as we now do, were it not for the fact that the New York Railroad Commissioners insist on our doing it.

We have no hot water arrangement for washing out our

boilers. We still continue to wash them out in the old way with cold water, letting them cool down sufficiently, washing them out, and firing up, as we have done for a number of years, so therefore I can not add anything to what has been said on the modern washing-out plants.

MR. VAUGHAN: I would ask Mr. Bentley a question. No doubt when we were putting water in through the injectors, we were doing about the worst possible thing that could be done to cool off the boiler, according to what Mr. Wells told us, and which I believe resulted in cooling it off at the bottom and leaving it hot at the top. I would ask, in connection with the washing-out plants you have investigated, in your duties on this committee, is it customary, after blowing out the water, which takes about twenty minutes, and taking out the plugs, to put this water at a temperature of 140 degrees, right into the boiler? We did that. We have two or three washing-out plants, and it takes about forty minutes from the time we start until the plugs are out. We put in hot water, and there is steam from the boiler wherever the hot water strikes. If we use hot water in washing out, at a temperature of 140 degrees, there is a difference between the temperature of the hot water and the temperature of the sheets and flues of about 200 degrees, so the boiler has not cooled down in the twenty minutes at all. I think the temperature of the sheets and flues is up to 350 degrees at the time the blow-off is completed. The result of this is that when we start washing out there is a portion of steam wherever the water strikes. We have had no trouble with that and I would like to know if we are using the system the same as everybody else. It is possible that a series of small local contractions do less harm than a heavy contraction caused by a mass of cold water at the bottom, and hot water at the top, which strains the boilers.

Our washing-out plants are simple — we simply use one tank, which in some cases we have connected up to use as a feed-water heater for the roundhouse boilers, and make an economical arrangement, and the washing out is not by any means the one advantage of this thing. Time after time one may desire to blow down a boiler and fill it up quickly, and the washing-out system, with its separate blow-off line leading out to the roundhouse, and filling-up line, is splendid.

We have a system in which we use three lines, one hot-water line, a cold-water line, and a blow-off line. We combined the hot and cold water at a union box to get the different temperature, or when we want to blow off we have the hot water to use for filling up. That is a great convenience, and we would like to have it at all our terminals, although it is quite an expensive installation, comparatively speaking. I am very much interested in knowing about this washing out with hot water, whether it is possible to put hot water into the boiler the moment the water is blown out, without cracking the sheets.

THE PRESIDENT: I believe Mr. Ellis has a lot of literature which he has collected in regard to this subject, and I understand that he has given a good deal of time in studying the subject and we would like to hear from him.

MR. J. J. ELLIS (C. St. P. M. & O. Ry.): In regard to washing out boilers we have a system of piping in our roundhouse for blowing off the engines, and have a washing-out system in which we use hot water from 130 to 140 degrees. After the engines are blown off we allow from 20 to 40 minutes for boilers to cool off before starting to wash. This works all right and we have no cracked sheets. I do not believe in blowing out a boiler and washing it right away. I believe we should give it a reasonable time to cool off to insure uniform temperature.

MR. ALFRED LOVELL: In reference to Mr. Vaughan's inquiry as to how other people are using the hot-water washing-out arrangement, I would say that about a year ago I was instrumental in the establishment of a plant of this kind at a place where very large engines were used, some of the largest Decapod engines, with trailing wheels.

The former practice was, after blowing off the steam, to keep the crown sheet covered with hot water and introduce cold water through the check valve, until the water was cooled down to about 90 or 100 degrees, before withdrawing the water and washing out.

My instruction after installing the new hot-water system was, to continue this practice of cooling down the boilers, and cool them until there was no more difference between the original temperature and the washing-out temperature, than there was

originally in the cold-water method. It was found in doing this that there was not very much saving in time by the hot-water method. The difference in cooling down from 350 degrees to 110 or 120 degrees, which is about as hot as one can wash out, is not very different from cooling down from 350 degrees to 60 or 70 degrees, so that the time actually saved in washing out by that method was not very great.

We then adopted the method which Mr. Vaughan speaks of, of drawing off the water, and immediately washing out with hot water, as hot as the workmen could handle in the hose, about 130 degrees. That method has worked satisfactorily, and as far as I know, there has never been a cracked sheet; up to six months ago there had not been one and the system had been in use about a year. This method of washing was contrary to my ideas of what would be best for the boiler sheets, but was adopted as a standard to get the best results, or greatest saving, by the hot-water washing-out system.

This system was so arranged that the steam was blown off through some brass tubes, in some heating tanks, which heated the water for filling up the boilers. Any surplus steam went to a settling tank under ground, into which the water from the boilers was run out through an underground pipe, after the steam had been blown off. The steam was blown off through these heating tanks first, and the water drawn off through the pits, and run into the settling tank under ground. The washing-out water was pumped back out of the settling tank to wash out the boilers. That was found to be as hot as the workmen could use it, and it was necessary at times to use cold water with it to temper it down. After a boiler was washed with this waste water, fresh water was taken from the heating tanks, through which the steam had passed, with which to fill the boiler.

I think by the old method of washing out, it took from 7 to 10 hours to cool a boiler down, wash it out, fire it up and get steam enough to get it out of the roundhouse. Under the new arrangement, I think it takes 2 hours and 50 minutes to do the same work; possibly 3 hours, or something in that neighborhood.

Mr. Wildin: In the locality where I am at present we wash

locomotive boilers once every thirty days, at which time we have to test the stay bolts to comply with the law.

I would like to inquire of these gentlemen who have spoken of introducing water of 140 degrees into the boiler how they handled the matter in case of stay-bolt tests. It would not be necessary for us to wash out the boilers once in thirty days if we did not have to test the stay bolts to comply with the law. The advantages of the hot-water system do not appeal to me as completely as they seem to appeal to other gentlemen who are present.

MR. LOVELL: I will state that this plant I have reference to was located where the boilers required washing every round trip. It was a bad-water territory, a good deal of alkali in the water, and it was necessary in one direction to wash out every round trip. In the other direction some of the engines would run two round trips, but not always.

MR. CURTIS: I think there can be no doubt about the advantages of a hot-water washing-out system. It is also my opinion that locomotive boilers should not be cooled any faster than you can cool the water in the boiler. There are several methods of doing this. One is to apply injectors and work them until they break on account of reduction of pressure. And then we prefer to force cold water in on the hot water until the boiler is cooled under pressure to the atmospheric pressure. We can also blow off the boiler by blowing off the steam and then introducing the cold water into the hot water. It is my opinion that to put hot water into a hot boiler, as Mr. Vaughan spoke of, is wrong. It produces what I call a baking process. You must let the water go down in the boiler and what mud is in the boiler should be allowed to settle. If you do not do this, the latent heat in the metal will bake this mud on the boiler and make it harder to wash out.

To obviate this, you should have the plugs so located and a set of blow-off cocks that you can start the water running out of the bottom of the boiler, and commence to wash out about the time the water recedes to the height of the top of the crown sheet, and commence to wash right on the hot water; in that way you will find the mud is very thin and easy to remove, and

as the water recedes in the boiler, keep washing down in the boiler, and you will find you can get a great deal more of the mud out of the boiler.

As to the care of locomotive boilers, I wish to here state some facts, and not an opinion, for it is of great importance to obviate the necessity for washing out boilers. On the Louisville & Nashville Railroad, between Mobile, Alabama, and New Orleans, Louisiana, there is brackish water and it is necessary to wash out the boilers every round trip, about every 280 miles, and change the water in between washouts. We applied a system, involving the use of about seven blow-out valves on the boiler, and the introduction of boiler oil, and we now have found it possible to run these engines from 6,000 to 7,000 miles between washouts, when using this blow-out system and boiler oil. This water does not contain mud. On the other hand, we have, between Louisville, Kentucky, and Cincinnati, Ohio, water that comes from the rivers and clay banks, and that is full of clay, and the boilers require washing out every other round trip, making a washing out necessary every 440 miles. We applied the blow-off system and introduction of oil to which I have just referred and we are able to increase the mileage of these locomotives from 4,500 miles to 6,000 miles per month by the use of this blow-off system.

I mention this because it is something which may be of interest to you, and can be seen any day, if any one wishes to investigate it. The system obviates the necessity of washing out the boiler to a large extent.

MR. SANDERSON: There is no question at all about the benefit of using hot water for washing, as hot as the men can stand handling the hose pipe, and still less question about using hot water to fill up with, but I entirely agree with Mr. Curtis in what he said about cooling the boiler down. The great American hurry-up process is bound to get us into trouble if we do not look out. I will illustrate what Mr. Curtis has said about manufacturing scale in the boiler to give you trouble where you have bad water. Most of us are familiar in passing the hurry-up American restaurants with the sight of a nice-appearing cook in the window, with a white apron and a cap, making griddle cakes

on hot plates. If they are not particular to take the griddle cakes off at the right moment it burns on the iron. When there is a soft sludge on the inside of the boiler that is the process which occurs, and the sludge is turned to scale on the sheets, and you can not wash it off afterward.

It may be wrong, and possibly cause trouble to turn cold water into the boiler in such a way that the boiler is strained by unequal expansion and contraction, but that can be overcome by making special provision for distributing the water through the boiler, or doing as Mr. Curtis does, and I believe it is all wrong to attempt to wash the boiler until you have the temperature of the metal sheets down to such a degree that the mud and slime will not burn onto the sheets. You can not wash it off if you do, and there are many places all over the boiler, especially the flue sheet, where you can never reach it with a jet of water with any nozzle. I think we should guard against manufacturing scale in the boiler where you have water which will produce such conditions.

MR. GAINES: In reply to both Mr. Curtis and Mr. Sanderson and to just call attention briefly to a method I am using for cooling down which seems to give very good results after the steam has been blown down to atmospheric pressure, I may say, that I take a stream of cold water and put it into the boiler through the feed pipe and continue cold water running, and removing at the same time the back-head wash-out plugs located about four inches above the crown sheet, until the cold water comes out of those washout plugs above the crown sheet. When the temperature gets down so that a man can put his hand in, say one hundred or lower, then we consider it safe to go ahead and empty the boiler out.

MR. CURTIS: I wish to say something in addition to what I have been talking on to-day. I have been surprised to find in washing out with this method of cooling the boiler down with water, that the crown sheet is black when washed with water on the sheet, but if you allow the water to recede before you wash the crown sheet it will be gray or muddy colored, showing that the baking process has had an effect.

MR. HENDERSON: I would like to ask Mr. Bentley one more

question regarding that plant he spoke of. That is, whether the water, when it was let out was blown out with steam pressure, or did they let the pressure off the engine first? In other words, did they relieve the engine of pressure and then let the water merely run out by gravity, or give it a forcible blow-out with steam pressure back of it.

MR. BENTLEY: Mr. President, I was making some notes with the intention of answering all the questions that are raised and the points that are brought out, to close the paper, if that will be satisfactory to you.

THE PRESIDENT: If there is no further discussion we are ready for you to proceed now on that basis.

MR. BENTLEY: I think the point Mr. Vaughan brought up is a very good one to consider. There is no doubt but that the temperature of the boiler is higher than the temperature of the water that you put in for washing out. The steam mentioned by Mr. Vaughan as seen issuing from wash-out plug holes, when the colder water, say at 140 degrees, was turned in, was really not steam, but vapor, but I have known of places, not on our road, fortunately, where the boiler was at the same temperature as it would be when the steam was just blown off, and people have actually put cold water in, and damage was done.

A temperature of 140 degrees for wash-out water is so much better than other methods I have seen used (in one case they used cold water, forty or fifty degrees), and I am heartily in favor of anything that is an improvement over those methods.

I think the time mentioned by Mr. Vaughan for taking out the wash-out plugs, twenty minutes, is rather high.

Mr. Lovell's remarks about cooling off boilers, I think, is practically the standard method on most roads; to inject cold water into the boiler and allow hot water to go out until you finally bring the temperature down so that you can remove the plugs and wash out without doing any harm. But all of that sort of thing takes time, and what we are trying to do now, not at the present time particularly but in busy times, is to try and reduce the time it takes to do some of those things that are necessary. Mr. Wildin speaks about not having to wash out.

at the proper depth of slot we have assumed, as sufficient for common practice, a depth 3-16 inch greater than the nominal diameter of cotter. The proportions of castle slot thus selected make them susceptible to any method of manufacture, either milling, pressing or punching.

Obviously the castle nut requires in the bolt or stud and within the castle slot, some form of cotter or pin to prevent the nut from turning on the screw, and means must be provided to insure the proper location of pin hole with relation to depth of castle slot. This feature will be covered by a minimum distance from end of bolt to top of castle nut and another dimension locating the pin hole with reference to end of bolt. The dimension of cotter pin and castle slot, also dimensions of bolt end and location of cotter pin hole in bolt will be the same for both the castle nut and the thin castle nut.

After deciding on the standard size of cotter pins to be used and then designing the castle slot to correspond, the next step in the design of the nut is to consider its thickness. In doing this we assumed the 1½-inch nut as a starting or generating point. Then for the castle nut ¼-inch is added to the thickness of U. S. standard nut and for the thin castle nut ¼-inch was deducted. A minimum thickness of ¾-inch for ½-inch castle nut is required to give the proper castle slot proportions for the size of cotter selected. From this conclusion your committee was enabled to devise a straight line formula for the thickness of the castle nut and thin castle nut (see Plate No. 1) which would give results corresponding with their conclusions as to the proper thickness for the ½-inch and the 1½-inch sizes. Intermediate thicknesses are obtained from the formula. Notice that thickness of the castle nut increases by increments of ⅛-inch and the thin castle nut by increments of 1-16-inch for each ⅛-inch step in size of nut to and including the 1½-inch size. These formulæ if applied to the 3½-inch castle nut would give a thickness of 3¾ inches, and if applied to 3½-inch thin castle nut would give a thickness of 2¼ inches. These dimensions were considered as giving a nut entirely too heavy and were therefore arbitrarily reduced by ½-inch in thickness, making the 3½-inch castle nut 3¼ inches thick, and the thin castle nut 1¾ inches thick. A straight line formula was also devised covering the thickness selected for the 1½-inch and 3½-inch sizes. In these formulæ the thickness of castle nuts above the 1½-inch sizes increases by increments of 3-16 inch, advancing by quarters, and for thin castle nuts the increment of increase is 1-16-inch. These formulæ give, for the 1⅝-inch and 1⅞-inch sizes, a thickness in which a thirty-second dimension is necessary to express the thickness and to avoid this feature the next higher 1-16-inch dimension is used instead of the dimension found by the formula.

The thickness of nuts obtained by these formulæ are shown graphically on Plate No. 1, the full line giving the thickness of nut over all and the broken line giving the thickness of nut below castle slot. The thick-

with tell-tale holes, as well as requiring us to make the test once a month and submit this test bearing the seal of a notary public. I have not very much to say further than that. [Laughter.]

THE PRESIDENT: Gentlemen, I wish to call your attention to an innovation that we are going to introduce here to-morrow morning. It has been somewhat difficult to get our members around on time, but all those who are not here to-morrow morning at 10 o'clock will feel exceedingly sorry, because there is going to be a photographer here to take a picture at that time, and if you do not report, we will know all about it. So do not forget. Our meeting will open, of course, at 9:30 to-morrow morning as usual, and in order to be sure about that picture, get here promptly.

A motion to adjourn is now in order.

On motion, adjourned until 9:30 Tuesday morning.

TUESDAY'S SESSION.

President McIntosh called the meeting to order at 9:30 o'clock and said:

The first business before the Association this morning is the presentation of the report of the Committee on Castle Nuts, which will be read by Mr. J. F. DeVoy.

MR. DEVOY: Mr. Chairman and Gentlemen: The chairman of the Committee on Castle Nuts has asked me to read this paper, and I want to say before I start that the greater part of the work was done by Mr. Kendig, the chairman of the committee. I do not know but that perhaps, as far as my service on the committee is concerned, I obstructed the work more than I did any good, so that the real burden of the work was performed by Mr. Kendig. I do not think it is necessary to take your time to read the paper, so I will abstract it. The paper is as follows:

REPORT OF THE COMMITTEE ON CASTLE NUTS.

To the Members:

Your committee appointed to consider the use of castle nuts for the machinery of locomotives with a view of having some standard dimensions established would report as follows:

Concerning the use of the castle nut on locomotives, your committee can not too' strongly recommend its application to every important bolt on the locomotive and tender. Reports from various railroads which have made extensive use of the castle nut on locomotives indicate that a very appreciable reduction in the number of machinery failures is only one of the immediate results obtained.

In deciding on dimensions for the castle nut it was thought advisable to consider two thicknesses for each size of nut. One series for general use and which could be applied in the transition period to bolts already having cotter pins for retaining the U. S. standard finished nuts, will be referred to hereafter in this report as the "CASTLE NUT." Another series, which in the larger sizes in considerably less in thickness than the U. S. standard nut, for use in service, such as on valve motion parts, or other places where there is not sufficient clearance to apply a nut of full thickness, or where the strain on the bolt is in shear and in consequence

there is no direct tension on the nut, will hereafter be referred to as the "THIN CASTLE NUT."

Your committee took up the question with the various Associations of Automobile Manufacturers and Street and Interurban Associations to learn whether any attempt to standardize the castle nut had been made by their several organizations. It developed that the Association of Licensed Automobile Manufacturers had already adopted standards for castle nuts, but as their standards have a finer thread than the U. S. standard system for screw threads it was soon found that their standard could not be harmonized with the proportions of the proposed castle nuts with U. S. standard thread. The other associations mentioned have not adopted standards for castle nuts, and your committee therefore decided to take up the proposition on independent lines.

In deciding on dimensions for castle nuts and thin castle nuts your committee endeavored to follow, as far as practical, the proportions of the U. S. standard hexagon nut, with the result that the following features common to the U. S. standard hexagon nut can be followed:

The style of nut to be hexagon.

The width across flats, or short diameter of hexagon, to be same as the U. S. standard dimensions already adopted for the finished hexagon nut by the American Railway Master Mechanics' Association. No specific dimensions will be recommended for diameter across flats for rough nuts, other than that these should be practically the same as for finished nuts, simply allowing only sufficient additional material to finish by grinding and buffing.

Threads to be U. S. standard thread and number of threads per inch to be the same as already adopted by the Association.

There are, however, a number of large-sized nuts used on the locomotive, which, on account of clearances, their thickness does not permit the use of the standard number of U. S. threads, and with the coarser threads there is a liability of their working loose. To take care of such cases we have shown on Plate No. 4 the number of threads per inch to be used on this class of nuts, which will be known hereafter as the "SPECIAL THIN CASTLE NUT."

Number of castle slots, six; cut through center of flats.

Sizes of castle nuts and thin castle nuts considered: ½ inch to 2 inches advancing by eighths; 2 inches to 3½ inches advancing by quarters.

In designing the castle nut, the first feature for consideration is the size of cotter pin or taper pin to be used. For this we have devised the formula, Diameter $= \frac{D}{8} + \frac{1}{8}$ inches (where "D" equals diameter of screw), using the nearest commercial size of cotter pin to the dimension found by the formula.

After deciding the diameter of cotter the castle slot is next considered, and for this we have assumed a tolerance of 1-32 inch between each side of the cotter pin and the wall of the castle slot. In arriving

at the proper depth of slot we have assumed, as sufficient for common practice, a depth 3-16 inch greater than the nominal diameter of cotter. The proportions of castle slot thus selected make them susceptible to any method of manufacture, either milling, pressing or punching.

Obviously the castle nut requires in the bolt or stud and within the castle slot, some form of cotter or pin to prevent the nut from turning on the screw, and means must be provided to insure the proper location of pin hole with relation to depth of castle slot. This feature will be covered by a minimum distance from end of bolt to top of castle nut and another dimension locating the pin hole with reference to end of bolt. The dimension of cotter pin and castle slot, also dimensions of bolt end and location of cotter pin hole in bolt will be the same for both the castle nut and the thin castle nut.

After deciding on the standard size of cotter pins to be used and then designing the castle slot to correspond, the next step in the design of the nut is to consider its thickness. In doing this we assumed the 1½-inch nut as a starting or generating point. Then for the castle nut ¼-inch is added to the thickness of U. S. standard nut and for the thin castle nut ¼-inch was deducted. A minimum thickness of ¾-inch for ½-inch castle nut is required to give the proper castle slot proportions for the size of cotter selected. From this conclusion your committee was enabled to devise a straight line formula for the thickness of the castle nut and thin castle nut (see Plate No. 1) which would give results corresponding with their conclusions as to the proper thickness for the ½-inch and the 1½-inch sizes. Intermediate thicknesses are obtained from the formula. Notice that thickness of the castle nut increases by increments of ⅛-inch and the thin castle nut by increments of 1-16-inch for each ⅛-inch step in size of nut to and including the 1½-inch size. These formulæ if applied to the 3½-inch castle nut would give a thickness of 3¾ inches, and if applied to 3½-inch thin castle nut would give a thickness of 2¼ inches. These dimensions were considered as giving a nut entirely too heavy and were therefore arbitrarily reduced by ½-inch in thickness, making the 3½-inch castle nut 3¼ inches thick, and the thin castle nut 1¾ inches thick. A straight line formula was also devised covering the thickness selected for the 1½-inch and 3½-inch sizes. In these formulæ the thickness of castle nuts above the 1½-inch sizes increases by increments of 3-16 inch, advancing by quarters, and for thin castle nuts the increment of increase is 1-16-inch. These formulæ give, for the 1⅝-inch and 1⅞-inch sizes, a thickness in which a thirty-second dimension is necessary to express the thickness and to avoid this feature the next higher 1-16-inch dimension is used instead of the dimension found by the formula.

The thickness of nuts obtained by these formulæ are shown graphically on Plate No. 1, the full line giving the thickness of nut over all and the broken line giving the thickness of nut below castle slot. The thick-

ness of U. S. standard nut is given for comparison. Notice that in all the formulæ your committee has devised for the castle nut that the equations are given for convenience in terms of the diameter of screw.

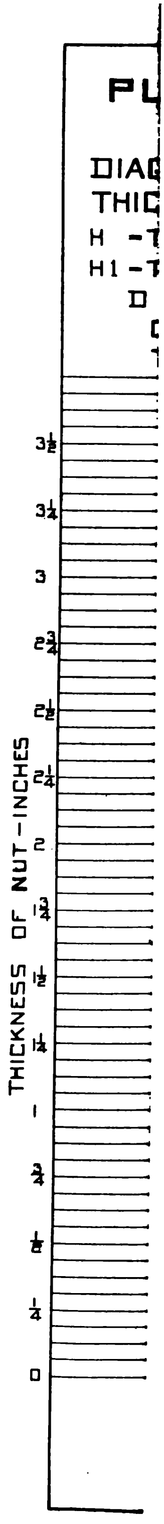
The proportions which will later be recommended for castle nuts and the formulæ by which they were obtained is shown by graphical relation on Plate No. 2. Likewise Plate No. 3 shows graphically the relation between various dimensions of the thin castle nut. Plate No. 4 is a table showing the dimensions for various castle nuts and the thin castle nuts. It also shows the formulæ employed in deciding these dimensions and results obtained from the formulæ. By comparing the latter dimensions with the recommended dimensions it will be found that your committee has eliminated the use of any dimensions in thirty-seconds of an inch, with the exception of the facing collar on bottom of finished nut, which is to be 1-32-inch thick.

Your committee wishes to submit for consideration of the Association a form of cotter designed by Mr. Player, of this committee, which overcomes some of the objectionable features of the common cotter when applied to the castle nut; one of the advantages being, that when put in place it can not turn around at will, and in consequence the liability of its rattling loose is diminished. Another advantage is, that a saving in the length of cotter, as compared with the common cotter pin, is effected. This cotter has not, to the knowledge of your committee, been patented and is given to the Association with the idea that all who wish may use it.

In the table of cotter pins (Plate No. 4) the sizes selected all appear in the manufacturers' standard list of spring cotters. While the practice is not general, some of the railroad companies are using a taper pin in place of cotter for retaining the nut, and for their convenience sizes of taper pins to be used in connection with the castle nut are given. The various sizes and lengths specified are contained in the manufacturers' list for taper pins.

In giving the dimensions for end of bolt it was thought desirable to show proportions of bolt with ends reduced below bottom of thread to present a plain surface for drilling the cotter pin hole. This is not necessary, however, as the same result can be obtained by filing a groove or flat to start the drill. On account of the necessary reduction of thread bearing and its consequent reduction in holding capacity of the nut, reduced bolt end should not be used with the thin castle nut, but instead the thread should be continued to the end of bolt. In preparing the end of bolt, so as to give protection to the thread, notice that the end is shown on the various plates preferably faced off flat for a distance equal to half the diameter of screw. The outer surface of end is chamfered for a distance equal to half the projection of bolt above nut.

In order to give each member a clear conception of the proportions, especially the thickness of castle nut and thin castle nut recommended,



PL
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¾
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THICKNESS OF NUT-INCHES

threads per inch, two holes should be drilled through bolt so as to allow of finer adjustment, but with nuts under 2 inches or on special nuts of larger size, with fine threads, one hole would be sufficient. To move nuts 1-6 of a turn on 3½-inch size (3¼ threads per inch) it would mean nut traveling .0513 inches, or nearly 1-16 of an inch.

On larger-sized nuts with standard thread, would suggest that slot be made ¼ inch deeper than diameter of cotter pin, as we find that on a 3½-inch nut (with 3¼ threads to the inch), with ½-inch pin 1-16 inch from bottom of slot, that by turning one revolution of nut it would travel 5-16 inch and the center of the cotter pin would only be 1-16 inch below top edge of nut.

MR. GIBBS: Mr. President, what have the manufacturers done in meeting this committee? Granting that this is adopted, have any of the manufacturers agreed to make these upon any terms? I went to see some of the manufacturers and they did not know anything about castle nuts, and had no standards, and in fact could not even tell me whether there was a standard. Possibly the committee can tell us something about that.

MR. DEVOY: I can only answer, as far as I am concerned, that the Milwaukee Road is making them now on a forging machine, in our shop. The National Automobile Manufacturers' Association is making them. They can be made anywhere. I believe the Lake Shore Road is making them in a different manner.

MR. H. P. MEREDITH (Penn. R. R.): Mr. President and members: In talking with a representative of the Russell, Birdsall & Ward Bolt and Nut Company, of Port Chester, N. Y., about castle nuts, he told me that they were prepared to make them, and they were simply sitting down and waiting until some standard was adopted by the railroads. As far as we have found out, in working up our report, there are about eight standards for castle nuts. The J. G. Brill people use one standard, the American Locomotive Company another, The Lake Shore & Michigan Southern have something that they were shooting at as an experiment. They had adopted a standard; and the Navy Department had used some few nuts which were

bought from the Russell, Birdsall & Ward Company, and other concerns have their own standards. So there are several standards, and the manufacturers say they are ready to make any design of castle nut as soon as a standard is laid down. They have made a good many nuts for the Licensed Automobile Association, which has a standard that would not suit railroad work.

THE PRESIDENT: While we are using castellated nuts to some extent on our road, I am free to confess that I do not know where we get them. Mr. Flory, can you give us any information on the castellated nut question about their efficiency or otherwise?

MR. B. P. FLORY (C. R. R. of N. J.): We have had a few castle nuts from the Russell, Birdsall & Ward Nut Company, and are trying them out now. We did not get up any design for them, simply took what they furnished us as their standard nut, or what they considered their standard at that time.

THE PRESIDENT: Is there any further discussion on this subject, gentlemen?

MR. GAINES: I am not quite clear, from the closing remarks of the committee, whether this question is supposed to be put up to letter ballot for a standard or not, but if there is any doubt about it, I would like to make a motion that it should be. I think we should come to some standard in regard to castle nuts. We buy engines from different engine builders, and each one at the present time has a different idea as to the castle nut, a difference not only as regards thickness, but as to the kind of cotter and kind of slot in the end of the nut, and I think it is important that the castle nut should be brought to a common standard.

MR. C. A. SELEY: I second the motion.

MR. MEREDITH: I think the Baldwin Locomotive Works and the American Locomotive Company have applied the castle nuts to a good many locomotives which they built, and I think it would be a good thing for us to hear from some of the locomotive builders on the question, and see what they have to say, and what they consider as a desirable standard. I know they have built some locomotives for our lines, and have built some locomotives

for other lines in the country, equipped with castellated nuts, and they may like to have something to say on the subject, to bring the various features of the question before the members of the Association.

MR. VAUGHAN: We use what the committee calls castle nuts, in place of castellated nuts, which I believe will be a good term for us to adopt, as it is a comparatively short term, and will be a suitable one for use in the future. We use this nut very extensively, and consider it the best and most practicable form of lock nut for locomotive use. We have our own standards, but I think the establishment of a standard like this by the American Railway Master Mechanics' Association would be valuable not only to the railroads, but to the manufacturers of bolts and nuts, but I would suggest that to make this a standard immediately would be rather a serious matter. It appears to me it might be more satisfactory to pass a resolution, making this a recommendation of the Association, recommended practice for a year, so that at the end of that time, we could find out if any objection is raised to the sizes or dimensions mentioned in this report. I believe firmly that a standard of castle nuts is required. We make them partly in the forging machine, but more often in the milling machine, as on small nuts we have found more or less difficulty in getting a sufficiently good job in the forging machine with the small cotters, and it strikes me as a class of article that requires special machinery developed to manufacture it, and that it is one that will probably go into the hands of the manufacturing concern rather than the railroads, who can hardly equip themselves with the necessary machinery to make the nuts cheaply in limited quantities.

I would like to propose an amendment that this Association recommends the dimensions of castle nuts formulated in this report for use by its members during the coming year, with the view of adopting them as standard if they are found satisfactory, and I believe the committee should be continued for a year, to get in touch with manufacturers of castle nuts, and with other parties with a view to establishing them as a regular standard at the end of the year, if nothing develops to the contrary. I offer that as an amendment to the motion which has been made.

MR. WILDIN: I second the amendment.

MR. GAINES: I accept the amendment.

THE PRESIDENT: The motion is now that the castle nuts reported by the committee be adopted as recommended practice for one year, and that the committee be continued.

Motion carried.

THE PRESIDENT: The next subject is the report of the Committee on the Apprenticeship System. Mr. C. W. Cross is the chairman of the committee.

Mr. Cross read the report as follows:

REPORT OF THE COMMITTEE ON THE APPRENTICESHIP SYSTEM.

To the Members:

Your committee, recognizing the fact that there is a wide difference in organization and local conditions as to available material and facilities for instruction, considers that a hard-and-fast general apprenticeship code is impracticable, and, therefore, suggests the discarding of the code adopted in 1898 and the substitution of basic principles rather than a formal code.

PRINCIPLES.

To assure the success of the apprenticeship system, the following principles seem to be vital, whether the organization is large or small:

First: To develop from the ranks in the shortest possible time, carefully selected young men for the purpose of supplying leading workmen for future needs, with the expectation that those capable of advancement will reveal their ability and take the places in the organization for which they are qualified.

Second: A competent person must be given the responsibility of the apprenticeship scheme. He must be given adequate authority, and he must have sufficient attention from the head of the department. He should conduct thorough shop training of the apprentices, and, in close connection therewith, should develop a scheme of mental training, having necessary assistance in both. The mental training should be compulsory and conducted during working hours, at the expense of the Company.

Third: Apprentices should be accepted after careful examination by the apprentice instructor.

Fourth: There should be a probationary period before apprentices are finally accepted; this period to apply to the apprentice term if the

candidate is accepted. The scheme should provide for those candidates for apprenticeship who may be better prepared as to education and experience than is expected of the usual candidate.

Fifth: Suitable records should be kept of the work and standing of apprentices.

Sixth: Certificates or diplomas should be awarded to those successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

Seventh: Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

Eighth: It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibilities.

Ninth: Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

Tenth: Apprenticeship should be considered as a recruiting system, and greatest care should be taken to retain graduated apprentices in the service of the Company.

Eleventh: Organization should be such as graduated apprentices can afford to enter for their life-work.

For the purpose of obtaining data as to the conditions on various roads of the country, information was secured which is summarized as follows:

1. A shop plant for the purpose of this report is one in which general repairs of locomotives or cars are made. Fifty-five roads report 301 shop plants having apprentices.

2. Fifty-five roads report 67 shop plants in which there are no apprentices.

3. Fifty-five roads report a total of 7,053 apprentices in shop plants.

4. Fifty-five roads report apprentices in each trade as follows:

Machinists	4814	Molder	82
Boilermakers	952	Electrician	14
Blacksmiths	311	Painter	137
Patternmaker	64	Upholsterer	27
Cabinetmaker	22	Carpenter	249
Tinner-pipefitter	365		

5. Reports from fifty-five roads show the average ratio of apprentices to mechanics in each trade to be as follows:

Machinists	1 to 4.8	Molder	1 to 8.2
Boilermakers	1 to 6.8	Electrician	1 to 8.6
Blacksmith	1 to 13.9	Painter	1 to 19.2
Patternmaker	1 to 3.3	Upholsterer	1 to 11.3
Cabinetmaker	1 to 23.3	Carpenter	1 to 72.4
Tinner-pipefitter	1 to 5.1		

6. The majority of replies indicate difficulty in securing apprentices in some of the trades, but no difficulty in others. A few replies state no difficulty in securing apprentices. This is apparently due to local conditions.

7. Out of a total of fifty-five replies, ten, or 18.2 per cent, indicate special instruction in trades is given apprentices. Forty-five replies, or 81.8 per cent, do not provide for special instruction.

8. Out of a total of fifty-five replies, sixteen, or 29 per cent, indicate an established school system and thirty-nine, or 70.9 per cent, have no school system.

9. Out of a total of fifty-five replies, thirty-nine, or 70.9 per cent, have apprentices and no school system, and eight roads state that they intend to establish such a system.

10. Eighteen replies favor day schools and three, or 14.3 per cent, favor night schools out of a total of twenty-one replies.

11. Fifteen replies show thirty-seven schools with 1,567 apprentices attending. The majority of the schools were recently established.

12. Of the above schools, twenty-eight are held in working hours and nine are held in the evening.

13. Of the above schools, thirty-four are compulsory and three are optional.

14. Out of fifty-five roads, twelve pay the apprentices for time spent in school.

15. Modern apprenticeship training has been introduced in seventeen shops on four roads with 506 apprentices since the convention of June, 1907. The following roads and systems of roads have made substantial progress in this work.

			No. Apprs.	Estab.
Union Pacific	1 school.	Omaha	71	9-1-06
	1 "	Cheyenne	21	12-1-07
Michigan Central	1 "	St. Thomas	36	12-1-07
Santa Fe	10 schools.		363	1908
Southern Railway	1 school.	Knoxville, Tenn.	...	1907
	1 "	Spencer, N. C.	...	1907
Delaware & Hudson	3 schools.	Green Isle, Oneonta, Carbondale	86	1907

Substantial progress has also been made on roads having schools previously established, on the Grand Trunk Ry., Central R. R. of N. J., Boston & Maine R. R., Union Pacific R. R., Minneapolis, St. Paul & Sault Ste. Marie R. R. and New York Central Lines.

The Canadian Pacific R. R. and the Erie R. R. advise they intend to install the improved plan of apprenticeship during the present year. Other important roads have the subject under contemplation.

These replies cover apprenticeship which is both new and old, some of the statements coming from roads of many years' experience.

The new apprenticeship, which combines instruction in the trade with mental training, is progressing rapidly on railroads, as described in answers to Question 15.

The results of these questions show how large a field is available for the new apprenticeship, as well as illustrating the extent of the present development.

Your committee believes that the strongest part of this report is embodied in the practical exhibit of apprentice training and methods in Booth No. 67 on the pier, which, it is hoped, every member will take opportunity to visit. This exhibit illustrates the development of the several roads in this matter up to date. The exhibit is worthy of most careful study, and your committee believes that the exhibit itself speaks in a far more definite and practical way of the details of the methods which are being employed than could possibly be put into words in even a very long report.

Your committee recommends that the Association provide an appropriation for establishing an exhibit of apprentice training to be a feature of each convention.

Your committee wishes to gratefully acknowledge the coöperation of the Railway Supply Manufacturers' Association in making the present exhibit possible.

An appendix to this report shows the present state of apprenticeship training in England.

It has often been said that apprenticeship is a thing of the past. This certainly is not true of American railroads to-day, where a new apprenticeship has sprung up and has attained a healthy growth with brightest promise for the future. Your committee does not hesitate to characterize the new apprenticeship as the most important influence introduced into railroad organizations during the present generation. This development is sure to be rapid, requiring great wisdom, combined with conscientious and systematic efforts in its control. We believe this movement will become the most powerful influence in supplying and preparing the men of the future for the motive power departments (and perhaps other departments) of American railroads; because the movement trains

men in the ideal way, and because men properly prepared for their work constitute our greatest problem to-day.

C. W. Cross, Chairman,
B. P. Flory,
G. M. Basford,
A. W. Gibbs,
John Tonge,
W. D. Robb,
F. W. Thomas,
Committee.

New York City, May 15, 1908.

This report is unanimous, except that in principle No. 2 Mr. Robb favors evening classes at the expense of the Company instead of day classes.

APPENDIX TO REPORT ON "THE APPRENTICESHIP SYSTEM."

RECENT PROGRESS OF APPRENTICE TRAINING IN ENGLAND.

Manufacturers and railroad managers in Great Britain have long been alive to the apprentice situation and have developed a number of successful systems embodying advanced and novel ideas. The subject has been given more careful consideration and fuller discussion than in this country and that more general results have not thus far been produced, is probably due to the natural conservatism of an older community and to the hereditary idea of class or caste, evidenced in the retention of many firms of the premium apprentice, a young man paying for the opportunity of entering the shop and usually given special privileges in learning the business. There still remain also in many cases long term apprenticeships of from five to seven years.

The British system of evening technical schools is such that each manufacturing center may be said to have its "Cooper Union." These district technical institutes, as they are called, are usually maintained jointly by grants from the Educational Board, by railroads and manufacturers, and to a small extent by the nominal fees charged for instruction. The use of such schools by firms having apprentices is quite general.

Several establishments make it a practice to excuse apprentices for six months of each year for attendance at day technical schools, crediting the time lost on the apprentice term, but it should be remembered that in such cases the apprenticeship is usually seven years. Both railroads and manufacturers appear to be united in placing emphasis on the value of technical education, and the offering of prizes for high scholarship in evening classes is a common practice.

The Lancashire & Yorkshire Ry. has built a mechanics' institute at Horwich, a point which is the location of large shops. Apprentices are supposed to attend evening classes at a nominal fee, and as a reward for progress, thirty boys are selected each year for free instruction during Company time for two half-days per week. The teachers are mainly from the Railway Company and the character of the instruction is such that many outsiders take the courses, paying increased fees.

The Great Western Ry. has day and evening courses with engineering and trade classes in the local technical school at Swindon. About forty-five per cent of the apprentices attend these classes. After one year in shop, apprentices may compete for day scholarships, consisting of instruction for two half-days weekly extending over twenty-six weeks per year for three years, the railroad paying wages for the time spent at

school, also the school fee. The subjects taught are practical mathematics, practical mechanics, geometrical and machine drawing, heat, electricity and chemistry. The number of scholarships at any one time is limited to thirty. In addition a limited number of apprentices are allowed to attend day classes, two afternoons per week of three hours each, without pay, and paying their own school fee. Apprentices taking full evening courses have the liberty of being late for shop the following morning.

For over sixty years the London & Northwestern Ry. has maintained the Mechanics' Institute at Crewe, where out of a population of 45,000 there are 8,500 men in the railroad shops and roundhouses, besides many in other departments. Schooling is optional except with electrical apprentices, who are paid wages for one afternoon per week instruction. Prizes are offered by the Company for progress in evening classes, which are taught, as a rule, by employees. The classes are open to outsiders, but employees are admitted at reduced fees.

One of the latest movements among manufacturers is that of Messrs. Clayton & Shuttleworth, who in February, 1907, decided "to graft the advantages of the bygone system upon the so-called factory system of modern times." The aim was first to supplement shop work with courses of instruction directly bearing on the work in the shops; and second, to give all deserving apprentices a varied shop experience. The movement through the shops was to depend on the proficiency of the apprentices. The firm was to maintain its own school in working hours, furnishing books and material free. A superintendent was to give full time to the apprentices. The apprentice regulations allow apprentices to enter between the ages of fifteen and twenty-two — sixteen to eighteen preferred — and offer a choice of eight trades. Machinists and patternmakers entering at eighteen serve three years. Molders, blacksmiths and boilermakers entering at eighteen serve four years. Schooling is compulsory in all cases. The aim is to make mechanics, but those showing ability to go higher will be given the opportunity. After twelve months of operation with fifty apprentices, the management reports slightly increased cost of production, but expects compensation in future benefits.

Another interesting system is that of Messrs. Brunner, Mund & Co., who in 1884 started voluntary evening class attendance at the public school, but soon made the attendance compulsory and offered prizes to those attending seventy-five per cent of the time. In 1904 school attendance was made compulsory for nine-tenths of the possible evening classes, and the rule was made to apply not only to apprentices but to other employees under nineteen. Since 1905, apprentices with three years' good record in evening class have been given two-year day courses — two afternoons a week under full wages. The report states that "this system was not commenced as a work of philanthropy, but as a matter of business." The work manager says: "Up to the present we have gained (1) a better understanding of mechanical drawing, (2) greater ability in setting up work. Up to a few years ago, few mechanics understood

a drawing — now many of our lads show great ability in hand sketching, placing their measurements on paper in an understandable form. It used to be the most difficult of all things to teach an apprentice to set up his work, but now in many cases it comes to him naturally. I consider that our younger generation of mechanics show a marked improvement both in ability and keenness for work, and it is a pleasure to deal with many of them on account of the interest they display."

Out of a list of fifteen firms described in recent issues of the *Engineer* (London), seven make a practice of sending the most promising boys while under pay and at the Company's expense to day classes for one or two days per week. The classes in most cases are at neighboring technical schools and the selection of apprentices for the day scholarships is usually based on competitive work in the evening classes. Eleven of the fifteen manufacturers advise apprentices to attend evening classes and three make such attendance compulsory. When an English firm intends to pay the school fees the accepted method appears to be for the apprentice to first pay the fee and later be reimbursed by the firm if he makes satisfactory progress or attends a sufficient percentage of classes.

Several grades or classes of apprentices are maintained by the British Westinghouse Co. and by Yarrow & Co., including a special classification for technical graduates.

The North-East Coast Institution of Engineers & Ship Builders have recommended a system of marks for apprentices, to include the attendance, industry and advancement in evening study, and the behavior and efficiency in the shop. Those apprentices reaching a given percentage of marks are rewarded by increased wages and by special opportunities for advancement. The scheme is designed to foster self-help and has been applied by several manufacturers.

A departure in student-apprenticeship courses has been made by the Sunderland Technical College. These courses, which were started in 1903, are open to apprentices in shipbuilding and engineering shops who are under eighteen years of age, who have already served two years in the shops, showing ability and giving satisfaction, and who have attended evening classes for at least two years. Boys are allowed leave of absence from the shops from October 1 to March 31 of each year to attend the college, the time counting on the apprenticeship term. A combination diploma is given signed by the firm, by the college and by the Association of Ship Builders and Engineers of Sunderland and District. The suggestion has been made that these courses be extended for nine months with classes repeating each two weeks, thus giving short alternating periods in shop and school, not unlike the idea being carried out in the United States by the University of Cincinnati.

Evening classes versus day classes is already arousing discussion in England. Evening classes have failed to produce the expected results. In a recent paper on the subject one investigator says that a large amount of evening instruction is wasted and recommends that evening schools

give assistance to enable a few to train themselves above the average, rather than trying to produce a light crop over a large area and attempting to reach the rank and file. The statement is further made that only a very exceptional youth, strong both mentally and physically, can make any great headway by evening study and at the same time work regularly and well in the shop from 6 A. M. to 5 P. M. In this connection the experience of Messrs. Cochran & Co. is instructive. In 1903 a three-year course of evening apprentice instruction was started, but in 1905 this was changed to day classes, holding sessions from 8 A. M. to 10 A. M. without deduction of wages. The results have been all that could be wished and the coaxing previously necessary to make boys attend evening class is no longer needed. Prizes are given boys who apply the school training in the shop. Messrs. Cochran & Co. report a direct benefit in the shop due to school work.

In conclusion it might be mentioned that nearly all the firms who are attempting to solve the apprenticeship question have abandoned the premium apprentice. Attention should also be called to the fact that there is but little reference to methods of handling the shop side of the question and no mention of shop instructors in connection with any of the roads or manufacturers, and it would therefore appear that the problem in Great Britain has been considered almost entirely along educational lines and hardly at all in the shop.

W. B. RUSSELL.

THE PRESIDENT: Gentlemen, we will consider this report received and open for discussion. It is a very important one and there are many here who are prepared to talk about it and relate their experiences. Don't hesitate to do so.

MR. A. B. MCHAFFIE (Intercolonial Ry.): It was a happy thought, I think, of the committee to make the exhibit as stated. Perhaps there is nothing better that will illustrate the progress of the apprenticeship work than is shown by the exhibit they have here.

MR. TONGE: I hope there will be no railroad in the United States or Canada that will ever ask an apprentice to attend an evening class. The company makes sufficient money out of the apprentice to be satisfied to give him an opportunity in the day class. It is the active mind that we expect to make use of; but after its daily labor it ceases to be active. We know that from experience. Anyone who has worked 10 or 12 hours a day knows what those conditions are, and I do hope that no railroad

will ever make such a proposition that an apprentice shall get his instruction after ten hours' labor.

MR. BENTLEY: I hardly agree with Mr. Tonge, because I know a good many Superintendents of Motive Power who have had to get all their training during the evening hours after their day's labor was over, and I am satisfied that if it had not been for their energy and persistence in seeking for education and information, they would not have been in their present position.

Our scheme of educating apprentices is not quite so elaborate as some of those mentioned, but nevertheless I think we are getting very good results. On the C. & N.-W. Ry., at Chicago shops, we have forty-five special and regular apprentices, and have two instructors who devote all their time to assisting and giving information and advice to these young men, and enable them to have every opportunity of becoming proficient in the work they are undertaking, and I think it has a wonderful effect, because the two men who are following the boys up all the time can help them out, and it is a very great assistance to the young men who are a little bit backward in their business.

We give a certificate or diploma as soon as the young man is out of his time, which shows where he served his apprenticeship and what course he has gone through.

I just want to call your attention to something that has been taking place on our road, to show you the interest the apprentices are manifesting. About twelve months ago the apprentices themselves organized an Apprentice Club, and they held fourteen meetings during the five months, the average attendance at those meetings being twenty-two, and to show you the scope of the papers and discussions they read, I will give you a few of them.

The first was, "The Future of the Apprentice." It was one of the best-written papers I ever came across; it set forth in very plain language that it was up to the young men themselves if they wanted to get anywhere, and that they had to work, not only in the day time eight hours, or ten hours, but occasionally burn the midnight oil when necessary.

The next paper was "The D Slide Valve," which was followed by "Stephenson's Link Motion," "Valve Setting," "The Air Brake," "Walschaert's Valve Motion," "Injectors and

Lubricators," "Front End Theory of Combustion," and closing with one on the "Indicator."

All of those papers were very ably presented and showed that considerable time and investigation had been given to the various subjects, by the boys.

The apprentices are under no obligation to join the club, the meetings taking place in the evening in their own time, but to show the interest displayed, it is enough to say that the whole of the forty-five apprentices are members.

The officials are always ready and willing to furnish them information, and to meet with them and occasionally give them a talk, which appears to be appreciated. From the above it would seem as if we still have some young men who are anxious to progress and make a name for themselves.

MR. GAINES: Mr. President, I want to agree with Mr. Bentley about the proposition of the night instruction, not taking any exception to what Mr. Tonge had to say relative to the parsimony of the railroads, but rather from the standpoint that it has been my experience that when an apprentice boy puts in his evenings studying somewhere in a school it is of decided benefit to him, and less wear and tear on his physical body.

There is another thing that is not touched on in this report that I would like to hear some one talk about a little more and that is the proper ratio between the skilled mechanics in the shop, what is the best ratio of the number of apprentices in each trade in relation to the skilled men, and whether or not there has been any trouble with organized labor limiting the number of apprentices. I would also like to call attention to the fact that I have found from experience an advantage from what you might call a preliminary training for apprentices. If you take them in as wiper boys, messengers, or other uses around the shop, and weed out the undesirable ones before you even take them in, or consider them as apprentices, you are apt to get a very much better class of material.

MR. F. W. THOMAS (A. T. & S. F. Ry.): Mr. President, I would like to make one statement as to the economical feature of adopting some advanced and practical method of apprentice instruction. At the Santa Fe Topeka shop, where we have our

largest apprentice class, 163 boys, we found from actual figures and work performed, that it cost us about 23 cents a day to instruct these apprentices in the shop. The average salary or daily rate of pay for apprentices is about $1.37 a day, making in round numbers $1.60 a day wages and cost of instruction for the apprentices. We find that we get eighty per cent as much work out of the average apprentice as we do out of the average journeyman in the shops, so that with an outlay of $1.60 in money, we can accomplish eighty per cent as much work as we can by paying $3.60. We find also, as a result of the shop instruction, that we can give a higher class of work to the boys. They are not only doing more work, but a better grade of work. We find also that in the event that some machinist is absent during the day, or for several days, we can put a boy on the important machine, and with the assistance of the instructor, keep that machine in operation rather than have the machine lay idle, or put a man on the machine who is not familiar with it or the work.

We have one or two of the Master Mechanics of the Santa Fe System here to-day. I would like, through the Chair, to call on Mr. Hicks of the Santa Fe as to the practical value of the advance system in the shops at San Bernardino. I think Mr. Hicks is here.

MR. WILDIN: I do not think there is any question about the value of the instruction given the apprentices. What I would like to know is, if we can increase the standard ratio of apprentices to skilled labor under the instruction method. Mr. Gaines asks the question, What is a proper proportion? Of course, we know what the proportion is at present, but the proper proportion is another thing; one to five is known to be the standard proportion. I suppose Mr. Gaines is affected like everybody else.

What I would like to know is, if we are ever going to get the proper proportion of apprentices to the skilled machinists by any method of instruction. Are the skilled mechanics averse to the men who pass through the school before going into the shop more than they are to the men who have gone through the wiping gang?

MR. I. C. HICKS (Santa Fe): At San Bernardino, on the

Santa Fe System, we use the improved system of apprentice instruction. We have a practical and a technical instructor. On the machine side especially, it is possible to have apprentices do the highest class of work, with the special instructor checking the work thoroughly. It gives the company a high class of work on the machines at a very low cost. This also applies to the other departments, and I find when the boys go through the shop technical school they take a greater interest in their practical work, which aids them in reading drawings.

Mr. DeVoy: I did not notice in the committee's report a statement that the Milwaukee Road has been doing anything, so I think it is probably in order for me to say something about our ideas on this subject. It has never been my opinion that it is absolutely necessary for a special apprentice trainer to be put in charge of the apprentices. I do not believe that any man is capable of properly training a machinist, likewise a boilermaker. Let the apprentice use the pattern shop, and they may train him at that place.

After giving the matter a year of study, since the last convention, it has convinced me fully that the Milwaukee system is still as good as where any special man is hired to train the apprentices. I would rather a boy of mine would go to the foundry foreman for his knowledge in foundry practice; I would much rather he would bump up against the patternmaker after he went into the pattern shop. I am emphatic in saying one thing — that any apprentice boy will do much better in the drawing-room if you put him there and give him three months' time, from start to finish. I do not believe that he can possibly obtain as much information in, say, one hour a day's instruction, carried over a longer period.

I am not at all opposed to the system as recommended by the committee, but I do still believe that there are systems of handling apprentices which do produce as good results as those mentioned in the paper.

Your committee has suggested that the Association provide an appropriation for establishing an exhibit of apprentice training, to be a feature of this convention, and at the same time it has been recommended by different members that the railroad

companies stand the expense of the training in place of night classes. Why not, then, the railroad companies stand the expense of providing the exhibition; it will interest them much more.

Unfortunately, we were not able to send the chairman of this committee any information in regard to this subject, but we feel that in another year we will be prepared to do something, and I believe that each railroad would do better if they would stand that part of the expense.

MR. J. H. MANNING (D. & H. Co.): I agree with the last speaker to the extent that it is impossible to get any one instructor who will be capable to take apprentices through the ramifications of all the different trades satisfactorily, but believe in combination with the instructor who is capable of instructing the apprentice in mathematics, drawing, etc., that there should also be an instructor in the shop. Now on our line we have that system — instructors who go from shop to shop, where we have schoolrooms, and give the apprentices instruction two hours a day in drawing and mathematics. We also have two demonstrators in the shop, and they not only demonstrate and speed up machines for the journeymen, but also give their special attention to the apprentices to see that they are moved along as they deserve.

I do not want to be understood as contending that this demonstrator or instructor we have in the shops is capable of going into the foundry or the blacksmith shop, or probably some parts of the machine shop (although that is his specialty) and fully and completely demonstrate what should be done in each and every case; but he can see that the boilermaker apprentice is moved along as we desire, and also that the boy in the foundry is moved along. He has supervision of the apprentices in the shop, in that respect, and in combination with the professor or instructor in mathematics, that I have mentioned, it works out very well, and we are entirely satisfied. We started in in a small way a year and a half ago with one school, with eight or ten boys, and now we have three schools, in fact one at each of our shops, and 100 boys. We have a report made showing the percentage of efficiency each month and in that way keep close tab on what the boys are doing. We are well pleased with what we have done along these lines.

Dr. Angus Sinclair: I think in the training of the apprentices the same principle holds as in the training of ordinary scholars. Some men have natural talents for instruction — others have not. One who has the natural faculty for imparting information will be of much greater value in the instruction of apprentices than one who has not, and I think that it ought to be the business of the shop superintendent, and those who are supervising the system, to see that the instructors are proper instructors that have the capacity for giving the information desired.

I had a very curious experience in securing instruction as a lad in a shop. Where I worked as a boy, the boys were just thrown into the shop and allowed to do as they pleased, pretty much anything, so long as the foremen did not see them idling. That was the thing you had to look out for, but so far as getting any special instruction, it was entirely out of the question. If you desired to learn you would probably get the opportunity from some good-natured mechanic, otherwise you would learn nothing. I have always felt under a great debt of obligation to a boilermaker I worked with for a few months, when I went into the shops as an apprentice. This boilermaker's name was Willie Lawrie. The first introduction I had to Willie Lawrie was one day just about the time I entered the works. We were waiting for the gate to open, and the boys were talking about the very interesting subject of what each one liked best to drink. When every one's opinion had been expressed, some one remembered that the expert Willie Lawrie had not been asked for his opinion, and they said, "Willie, what do you like best when you have a chance to take a drink?" "Well," he said, "when I have the option I just like a glass of whisky mixed with another glass of whisky as well as anything." [Laughter.] I was put on to carry the tools for this Willie Lawrie a week or two after that incident. He was known to be very hard with his boys. He never failed to make them do everything that they could do, and the dullest ones had the hardest time with him. After we had been working in the fire box for some hours,— this was my first experience,— when we went outside so that I couldn't look in, he said, "How many grate bars had that engine?" I said, "I don't know how many grate bars it had, I didn't count them." "Well, but

you were inside. How many were there?" and he insisted that I should make some kind of a guess how many bars there were. Then he laughed and made fun of me when I was far off from being correct. The next time he asked, "How many tubes were there in that boiler?" Then, "How many stay bolts?" "What is a stay bolt?" "What is it for?" and so on. The effect of this was that I was in a constant fever lest he should ask something that I didn't know, and I used to prowl around the boilers trying to pick up information about the thing so that I would be prepared for Willie Lawrie. That was a natural teacher, gentlemen. Those who have that kind of capability will bring an apprentice on much better than one who is thrown up just by the chances of the shop.

MR. MANCHESTER: Mr. President, a good many years ago, back at Saratoga, the Association discussed the question of an apprentice system. At that time I became very much impressed with the necessity for giving the subject thorough and careful attention. We went home and adopted an apprentice course, defining what should be the instruction the apprentices should receive, and we have followed up that course from that day to this. In bringing that out we tried as far as possible to keep away from the hot-house product. We make it a practice on our system to carry the usual ratio of apprentices, not only at the shops, but at the roundhouses. We think that for practical railway work the roundhouse is the principal and most important place, and we want our boys to have a good and thorough knowledge of roundhouse propositions. At our main shop at Milwaukee we make almost everything and anything that is known to railroad use except chronometers. We have not yet gone into the manufacture of chronometers. In that way, by giving the boy an opportunity in all of the different branches of the work in all of the different shops, in the manufacturing end as well as in the maintenance end, we believe that we are bringing forth some men that are capable of holding their own in every line of business, and we believe that within the last ten years, since we have been working this system, we have brought out some boys who can design and manufacture and maintain anything that is used on a railroad. We have not felt it the right

thing to do to establish a school in our shop. We believe in the principle, "Seek and ye shall find; ask and ye shall receive; knock and it shall be opened unto you." We want our boys to get on to that line of training; let them be looking for the information, and if they do they will get it every time. I would not disparage any system that gives the young man an opportunity, but I still believe, as has been expressed by some of the other speakers, that it is better to let the young man do some of the pushing for himself. It is an old saying that you can lead a horse to water, but you can not make him drink. We believe in the principle of keeping the water where he can get a draught of it, but we are neither going to lead him nor force him to drink.

As to applications for apprenticeship, we find little or no difficulty in getting all the good material that we can use, and more too. In nearly every branch there is such a long waiting list that some of them become discouraged before they can get an opportunity to get in. When I first started preparing apprentices for the boilermaker's trade, I did so with a good deal of misgiving, feeling that for that particular line of business there was not going to be a bright lot of boys brought in, such as we would desire to have come into the service. You may imagine my surprise when the first set of examination papers was brought to me by Mr. DeVoy from the first lot of boys that we put into the boiler shop, when, if I remember rightly, their standing was something like 93. We have found it equally easy to get boys for all the different lines of work. I believe that what we should do is to give the boy an opportunity to work in different shops. The boy who learns his trade in one of our shops has the last year of his apprenticeship at the main shop, where he gets the manufacturing end as well as the repair end. It is along those lines we feel we have been reasonably successful in our apprentice work.

MR. C. H. QUEREAU (N. Y. C. & H. R. R. R.): Mr. President, I think it is safe to say that any man holding a position of responsibility at the head of a large organization, who is successful, is as truly educated, though he has obtained his education at night, walking six miles, as a friend of mine just told me he did,

as the man who had the advantage of a college education. All men are educated either through their own efforts or through opportunities given them. It is this education that I think we should all strive for.

Personally I had the opportunity for a good education, which, no doubt, has very largely influenced my activities, I hope my usefulness. If I had been left to myself I am certain I would have put forth no special efforts to obtain this education. But I had a father who saw the advantages of this experience. He said to me, " My son, would you like to go to college? " I said, " I don't know that I care much about it." " I believe you had better go," he said, and I went. I believe the same principle would apply in this matter of the schooling of apprentices. There are lots of young men, who are bright, who have not had the opportunity of thinking for themselves. If they are invited, perhaps urged, perhaps commanded, to take a course, the result will be of benefit, not simply to them but the whole organization.

I had the good fortune to be in charge of some shops for two or three years with about 400 apprentices. I believe the conditions there were not exceptional at that time.

There was nominally a record of all those boys and a schedule which they were to follow giving them so many months in this department, so many months in that department — a carefully thought-out course. The facts, however, on investigation, did not coincide at all with the schedule. There were young men who had been three years in the erecting shop who were supposed to be finished machinists when they came out. There were boys who had been eighteen months on a certain machine because the subforeman was being pushed to complete his output. This boy was an adept at this tool and the consequence was he stayed there. We all know how that is.

The superintendent of shops had not the time to personally supervise the training of each of those four hundred apprentices. The result was confusion worse confounded. The result was a class of half-baked machinists when the job was done. I believe at that time these facts were paralleled in almost all shops of the same size. A record was made of the apprentices, and as nearly as could be determined, the length of time they had been in

various departments, with an idea of straightening out and getting the best possible that could be got under the conditions of work done by the clerks in the office, the different foremen, such time as they could give to it; but with these efforts the results were not produced which should have been produced.

For the reason which I have indicated, I am thoroughly in sympathy with the outline of the apprentice work given by this committee, and I wish to subscribe to every one of the suggestions given. The most important part is that there is some one who has charge of these apprentices who has nothing else to do. He will be judged by the results he produces. Under the old system that was an impossibility. The Superintendent of Shops, the General Foreman, and other foremen, were judged only by the work that was turned out and by the cost, overlooking the most important part of the shop, which was the machinist which was to come.

I, personally, very much doubt if we should figure on the cost of output of apprentices under this system. That, of course, is something to be considered; but we are not aiming, as I understand it, and it is not the idea of this committee that this apprenticeship cost should reduce the cost of the labor-producing efforts of the apprentice. It is to produce first-class machinists, and while the cost of this work is a consideration, it seems to me it should be one of the very minor considerations, and not worth emphasis at all.

A very live influence, it seems to me under this system, is the personal touch of the company through their responsible men, with the apprentices. There is a personal relationship, the value of which can not be counted; and I believe that in the years to come, if not already, the relations between the company and the men will be found to be much more harmonious than they have been under the older methods and systems. I believe they are beginning to feel and will more and more feel that they are a part of the company — that it is not a separate organization up aloft directing the work below, producing the largest output for the least cost. There is a community of feeling which is bound to tell all along the line, and the influence of this association, the influence of this personal contact, must be for the best of the men. It can not be otherwise.

Mr. E. A. Miller (N. Y. C. & St. L. R. R.): Mr. President, I think the report very good and the work of the committee such as to be fully appreciated. I agree with the committee that there should be some one in charge of the apprentices, to look after their interests and to see that they have the proper instructions and opportunity to advance. I also feel that we are under obligation to the New York Central, Pennsylvania and other roads that have adopted advanced methods, as shown by the report that we are now discussing, relative to the apprentices in our shops.

The President: Mr. Vauclain, we would like to hear from you on this subject if you will be kind enough to give us your ideas in relation to it.

Mr. Vauclain: Mr. President, Gentlemen: This subject of apprentices, whether it be in a manufacturing establishment or in a railroad shop, is a very important one, and is of great interest. Those of you who have had bother with labor troubles, after they had carried on a training school for four or five years, will appreciate more fully than any others the benefits to be derived from a system of this kind.

For many years we undertook to train our apprentices in the ordinary old style fashion, simply taking them into the works and allowing the foremen to supervise their instruction, and moving them about as their work in any department warranted. We found it necessary to remove the apprentice boy from under the supervision of the foreman and place him under the charge of a superintendent of apprentices. We have had a system of that sort in practice for about seven years, and it has been highly beneficial to us. We now do not need to consider going outside to hire skilled men, as we make more skilled men than we can find places for, and these men are eagerly sought for by outsiders.

So far as the training of boys is concerned, we believe there is room for all classes, in the technical training of boys, and we have three systems of apprenticeship. One system requires the boy to serve four years. This boy is the ordinary roustabout. He has probably gone through the grammar school and is unable to go any further, either because he is not sufficiently smart, or

does not care for book knowledge, or his parents may not be able to carry him any longer. The next class comprises those boys from the high schools or preparatory schools whose parents have not the means to send them to college and feel that their boys should learn a trade which will enable them to make a decent living in after years. Some of these boys are unable to go beyond the high school. They would not be successful in going into college, and therefore it is even more desirable that these boys should be taken into the workshop and be taught how to use their hands, or if possible, their brains in addition to their hands. These boys make a very desirable class of apprentices. The next class, the third class of apprentices — we do not call him a third-class apprentice because he is a graduate of a technical school, but simply because we first consider the grammar-school boys of which we have the largest number — is the technical graduate. The technical boy is the most desirable boy, and there is room for a great many of them as apprentices, but not room for so many of them after they get through with their apprenticeship. Their attainments and ability are such that they are quickly called to higher places than that of an ordinary mechanic.

It is desirable, however, to have as many of these technical-graduate apprentices as you can persuade to come with you. It is unwise, however, to offer them or hold out to them special inducements to bring them to you for fear that they may be disappointed. I have made it a rule for the first six months to compensate a technical boy sufficiently only to pay his board and a few minor living expenses. If he has the necessary nerve to work for six months under those conditions, we are ready to go on with him, and he is also very glad to keep on with us.

I want to say that the technical boy who comes to us need not necessarily be a graduate. A great many boys who go to college fall out after the first, second or third year — for some special reason they fail to pass a certain examination and they find themselves in such circumstances that they do not care to continue their college course for fear it will carry them over an additional year and stretch the course out from four years to five years. I would advise everybody to get as many of these young men as they can secure. I really believe, for our business,

these men are often more desirable than those who continue on and continue their course, and graduate at the top or the head of their classes. We find that these men are perhaps, a little slower in matters relating to the finer technique connected with a railroad or manufacturing establishment, but they are slower thinkers and stronger thinkers, and make stronger men in developing the capacity of handling their fellow men, to a much greater extent than the other men.

The very finest men we get from the various universities are those we have to use on the finer work, and who do not care to wrestle with the coarser grade of men. It is also found that unless this man is able to become one of these men, or to show his superiority among these men as a leader, that they never will respect him, and consequently he can not get the maximum amount of work from the under class that he can, if he in some way brings himself down to their level and is able to do the things which they do in the same length of time and with the same amount of satisfaction, and where a man is apparently too smart or too good to undertake these things, he receives the contempt of the majority of the men and is relegated by them, and not by us, to positions that he is well suited to, and the other man steps up and takes his place as a leader of men. [Applause.]

THE PRESIDENT: Mr. Flory, as a member of that committee, we would like to hear from you.

MR. B. P. FLORY: The school in connection with the Central R. R. of New Jersey has been established for about three years. We have been following the same line as some of the other railroads, and our ideas are embodied as part of this report. We are very well satisfied with the progress which we have made during that time, and see no reason for making any change. We have our school in the day time and believe that is the only time to have the school. There may be some local conditions on other roads which would make it better to have a night school, but on our road our large shop is located at a point which makes it necessary for nearly all the boys to live in another town, and it would be absolutely impossible to have evening classes.

In addition to having our boys under general instruction at the shops, we also bring them, as many as we can, to the

drawing-room for three months' instruction, and after they go back to the shops they do not receive any instruction in the drawing room in the shops any further.

With the organization in our shop, we have not yet any shop instructor. We have one general foreman on the machine side, and two subforemen, and with these and gang foremen, and the general foreman, on the erecting side, we are able to take care of the students in the shop fairly satisfactorily. The details of our organization, I think, have been presented to you before, so it is unnecessary to go into that matter any further.

THE PRESIDENT: We would like to hear from Mr. Deems.

MR. J. F. DEEMS: Mr. President and Gentlemen: I do not think I have anything to add to what has already been said. As I said at the convention, I think last year, in my opinion about the best way to handle this subject is to go ahead and try it out. As to those who have not tried it, I believe if they will they are certain to be satisfied of the value of it, as I think all are who have tried it, and what is needed in this case is not very much talk, but a good deal of work.

THE PRESIDENT: Mr. Basford, can we not hear from you on this subject?

MR. J. M. BASFORD (American Loco. Co.): Mr. President and Gentlemen, I was very much impressed in hearing the remarks from the gentleman from the very far West. We can not fail to be impressed by the way in which this new apprenticeship system has gone across this continent in two jumps. It is now likely to go North and South and perhaps across the continent in several other places. Its impetus is altogether too great to be stopped. The outlook is very encouraging.

I would like to speak of the last paragraph on page 5 in which the committee says: "It has often been said that apprenticeship is a thing of the past." As a matter of fact, apprenticeship is a thing of the past as the word apprenticeship is generally understood to-day. It is good that it is a thing of the past. If we want the apprenticeship which we need now, we must go back to the very beginning, where the master had but one apprentice, for some of the principles which we need to apply to-day. We

will find, however, when we go away back to that age, the life of the poor apprentice was not entirely happy. What we want to do is to apply some of the principles of instruction which applied at that time. Then the master had the services of the apprentice for perhaps nothing in wages, and it is possible that the apprentice sometimes paid something for the privilege of being a servant. The master made it his business to see that the boy was as useful as possible to him, and naturally gave him all the attention in the matter of instruction that it was possible to give. There was no lack of information in the old days. The whole question, it seems to me, at the present time revolves about the matter of instruction.

I would like to call your attention to the middle portion of that paragraph wherein the committee says: "This development is sure to be rapid, requiring great wisdom, combined with conscientious and systematic efforts in its control." The movement has only started. It is sure to be rapid. It will require the very best attention and the best care on the part of everybody in order to get the results that are so greatly needed to-day. This movement will not take care of itself.

At this point I would like to speak of what seems to be a misconception in the report of the committee on the matter of instruction. The committee has not, as I understand it, the remotest idea of suggesting that instructors should teach all trades. What the committee means is that the Chief Instructor should make it his business to see that the trades are taught, which is not now generally done by anybody. This matter of instruction reaches the heart of shop practice. What we require to be taught is shop methods; not the old shop methods, but better shop methods. It has been said that the foreman can do this. With all respect to the foreman, he can not do it.

The apprentice instructor needs a strong backing. He needs to have an active part in the management of the shops. He needs to be practically the right-hand man of the shop superintendent, because he is directly the man upon whom the shop superintendent is soon to rely for the best work he can produce. It will require eight or ten years to work it out and see the results, but sooner or later the man who has charge of instructing

apprentices will be one of the most important members of the mechanical organization of a railroad. It will devolve upon him to teach improved shop methods, to see that one shop is not doing one thing one way, and another shop a different way; it will be up to him to find the best way; to make a study of the proper grinding of tools, to know the proper shape of a tool for a certain piece of work, and know why it should be so, and to introduce the very best methods in all details generally throughout the entire railroad system. That may possibly have some effect on the cost of work a little bit later.

It is not going to be so easy, gentlemen, to get these men. That is one of the greatest difficulties to-day, because you wont find a man who can not only do as well as you are doing, but you want a man who can reach out and know the best work that is being done anywhere in the country, and who can apply that system in your work and teach it to the organization in your shops.

There is another side to this question of the shop instructor which was suggested by a gentleman sitting near me. The instructor needs to be a "daddy" to the boys. He needs to be one who stands in such close relationship to the boys that they will come to him as a friend in their troubles. In that way he will gain influence over the future organization, the value of which can not be estimated.

I would like hurriedly to refer to several of the principles set forth on page 2. One is: "Suitable records should be kept of the work and standing of the apprentices." It is very easy to say that; it is very difficult to carry it out. It is a very difficult thing, in any case, to carry out good records of what any man does, especially an apprentice, yet this must be done.

The sixth paragraph reads: "Certificates or diplomas should be awarded to those successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value." Some of us know the value of diplomas issued by some of the old manufacturing establishments, which have had apprentices for the last thirty or forty years. Such apprentices have no difficulty in securing work, and a diploma of such establishment means some-

thing when presented with a request for employment. There are certain manufacturing establishments in this country which have had a system of apprentice boys for perhaps half a century, whom you are all glad to get. Railroad apprenticeship diplomas do not, as a rule, to-day, mean very much. When they are as highly prized as those of the establishments referred to, this work will begin to show the results which we confidently expect.

MR. DEEMS: If I may be permitted, I would like to say one word, or a few words. Our President yesterday in talking to us said he had been called upon to attend a meeting at Washington composed of the governors of the various States of the Union, and other important business men, to discuss the question of the conservation of our natural resources. I recall having read the proceedings of that meeting, and the thing that impressed me perhaps most was a report, I think by Secretary of Agriculture Wilson, who brought out the fact that from year to year the soil in the West produced less and less and less. And he said: "Now, gentlemen, remember if you are going to get something out of that soil you have got to put something into it."

I feel the same is true in the matter of railroading in a large way to-day. If we are to go on and progress as we should, we must put something into the soil; that is, we must give these young men a better opportunity to qualify themselves to fill positions which will be open to them. That will make better men of them, and that in turn will make better communities, and better communities will be better for the railroads. The better men we have in the shops, the better the communities will be, and the better the community is, the better it is for the railroad running through the community, so that, in the end the benefit will be twofold. I think the more we keep this in mind, the greater the advantages will be to our industry, and as Mr. Basford said, at the end of ten years we will be more than pleased at the results obtained.

THE PRESIDENT: Mr. Cross, we will be pleased to hear from you in closing the discussion on this subject.

MR. CROSS (N. Y. Central Lines): The remarks of Mr. Tonge are worthy of special consideration, as he is a veteran in

the service and has been a champion of apprenticeship for a great many years.

The apprenticeship club described by Mr. Bentley will, no doubt, prove to be an important factor in increasing the fellowship of the apprentices, and they will all reap great benefit from this voluntarily chosen opportunity for self improvement.

Mr. Gaines said that if a boy puts in his evenings studying, it is of decided benefit to him. There is no denying this fact, but it has been demonstrated that much better progress can be made with the boys with benefit to the company employing him, if he is given school instruction during working hours, which will thereby enable the company to use him to better advantage in their service. It is also well to note that under this plan the apprenticeship is more attractive and a better class of boys can be secured.

Mr. F. W. Thomas, Supervisor of Apprentices of the Santa Fe, gave a very short and modest description of their apprenticeship system. The fact is that the Santa Fe has developed this work to an admirable extent and that the company is reaping the benefits already with prospect of still further good results.

In reply to Mr. Wildin, would say the skilled mechanics have no prejudice against the boys who receive the combination shop and school training. Quite the reverse is the case.

Mr. Hicks of the Santa Fe described the benefits he has received in his shop from the use of the special instruction. This testimony is of special importance because it represents experience on the Santa Fe Road, a road which has gone into this subject very thoroughly.

Mr. DeVoy does not believe it is necessary to have a special instructor for apprentices. It is not the intention to presume that the instructor could possibly be expert in all trades; his position is rather to supervise the course of the boys through the shop and the control of the boy is under the foreman as usual. I feel quite sure that although the Milwaukee Road has an excellent system of apprenticeship, it could be made still better by adding the feature of shop instruction and school attendance during working hours, with the boys given a chance in the

drawing-room, as mentioned by Mr. DeVoy, made a part of the apprentice course.

Mr. J. H. Manning of the Delaware & Hudson has the right idea and is doing excellent work on his road. The shops on his road are in the midst of a manufacturing vicinity where it is difficult to secure young men of the right sort. We understand the results which have been obtained by apprentice training have thus far been very satisfactory.

Mr. Sinclair emphasizes the necessity of carefully selecting the instructors. This feature is most important.

Mr. A. E. Manchester emphasizes the desirability of avoiding as far as possible the hot-house product in apprenticeship. We thoroughly agree with him. Also agree with him as to the desirability and importance from a company standpoint of giving the apprentice boy a good opportunity to learn the business in all of its branches. The excellent results being obtained by Mr. Manchester are well known, but could be improved by the use of a shop instructor and classes during working hours.

Mr. Quereau is fully conversant with the difficulties of carrying on an apprenticeship training without the use of persons especially trained to the work, and is also familiar with the benefits derived from the proper system.

Mr. E. A. Miller mentions the desirability of making the service attractive to the apprentice when he has finished his time. A little reflection will convince anyone that a young man who has served a proper apprenticeship is certainly worth as much to his employer as the average mechanic hired in the open market.

Mr. Vauclain emphasizes the desirability of special supervision of apprentices and also gives a few words of encouragement for a large class who may be called "ordinary" boys. These are the chaps, to use his language "who think slowly, but think thoroughly, and can be depended upon from year to year to perform loyal and efficient service." The boys with extraordinary capabilities will get along all right.

Mr. Flory described the excellent work being done on the Central R. R. of New Jersey under the supervision of Mr. McIntosh. My information is that their road was the first to

introduce day classes during working hours, and the company has derived benefit from the training of apprentices.

Mr. Basford expresses clearly what is intended to be the work of the shop instructor. He evidently believes this movement has now obtained such impetus that it can not be stopped. He also points out the necessity for guiding its progress carefully and well. The thorough coöperation and enthusiastic support of all the officials concerned is necessary in order to make the movement a complete success.

Mr. Deems expresses the practical utility of the apprenticeship system in his remark, "If you are going to get something out of the soil, you have got to put something into it."

The apprenticeship system described is intended to provide for recruiting the service by combining the shop instruction with the theoretical training. We feel that the work has now passed the experimental stage and has become a regular part of the work of railroads.

The specific value of this plan of training is that it enables the railroads to reap an immediate, as well as an ultimate benefit from the work done by apprentices due to the special training they receive both in the shop and schoolroom. The aim is to have a light crop over a large area, rather than a phenomenal growth of a few plants.

The progress made during the year indicates a substantial growth of the idea of apprenticeship training for recruiting the service. The apprentices everywhere acknowledge by their earnestness their gratitude for the opportunity offered for their self improvement.

At this time we could not do better than quote from the able paper of Mr. Basford, read before this Association, entitled, "The Technical Education of Railroad Employees — The Men of the Future," at the 1905 convention, as follows:

"The suggestion is that recruits in shops (and this applies in principle, though not in detail, to other service), should be taken in as apprentices. They should be given shop training which will increase their earning capacity to the utmost, and they should be placed under the direction of men of such character and

moral influence as to lead them to form correct, broad and honest views of life and their proper relations with other men and their employers. Parallel with the shop training, attendance during working hours at a school, provided and maintained by the road, should be required; and for this a new kind of school must be developed, as a new kind of apprenticeship must be developed — the kind that will meet the individual cases. They must be dealt with in classes or by fixed rules. The school must be one wherein the shop and the studies go hand in hand. While the shop hours are taken for the school, home work should be rigidly required. Life must not be made too easy for the apprentices."

MR. VAUGHAN: I move that the committee be congratulated on the excellent report and principles recommended by them; and that the report be adopted and that the principles recommended by the committee be endorsed by this Association as recommended practice and substituted for the code of apprenticeship rules adopted in 1898.

THE PRESIDENT: Gentlemen, you have heard the motion of Mr. Vaughan, that the recommendations of this committee be adopted to supplant the recommendations adopted in 1898.

(The motion was seconded and carried.)

THE PRESIDENT: The Secretary will read an announcement.

THE SECRETARY: The following resolution was adopted last evening at the meeting of the Executive Committee:

WHEREAS, A subcommittee of the American Railway Association has made certain recommendations looking to the coördination of the work of the voluntary railway associations with that of their own;

Be It Resolved, That the President of this Association be empowered to appoint a committee from its officers to confer with the American Railway Association when requested.

THE PRESIDENT: A motion to adopt this recommendation of the Executive Committee is in order.

MR. P. H. PECK: I move the adoption of the recommendation of the Executive Committee.

The motion was seconded and duly carried.

THE PRESIDENT: The next subject before the Association is

an important one. We will now have the report of the Committee on Superheating, Mr. H. H. Vaughan, chairman.

Mr. Vaughan presented the report.

REPORT OF COMMITTEE ON SUPERHEATING.

To the Members:

Your Committee on Superheating begs to report as follows:

During 1907 comparatively few engines were equipped with superheaters in the United States, although the Canadian Pacific Ry. continued to apply them to all road engines it constructed, 173 in all, bringing the total number of superheater engines on that road to 350, of which 110 are consolidation freight, 192 ten-wheel freight and 48 passenger engines.

The most important development in the United States has been with the "Baldwin" or "Vauclain" superheater, 52 engines having been constructed during the year 1907 equipped with this device. With this exception the only other engines constructed during the year with superheaters were two on the Union Pacific Railway, one of which was equipped with the "Vaughan-Horsey" smoke-tube superheater, the other with the "Union Pacific" smokebox type.

A statement of the engines equipped during the year so far as ascertained is as follows:

Road.	Type of Superheater.	No. of Engines.
C. R. I. & P. Ry.	Vauclain	1
P. S. & Northern	"	1
Central Railway, Brazil	"	2
Chicago & Alton	"	1
A. T. & Santa Fe	"	49
Central of Georgia	"	1
Union Pacific	Vaughan-Horsey	1
Union Pacific	Union Pacific	1
Canadian Pacific	Vaughan-Horsey	173

The "Vauclain" superheater may now be said to have developed beyond the experimental stage. It is of the smokebox type, in which the waste heat of the front end gases is utilized to superheat the steam on its way to the cylinders.

It is illustrated in Fig. 1, and consists of two cast-steel headers in the upper and two in the lower portion of the smokebox, the upper headers having a passage extending from the T-pipe flange at the back of the header to a cavity in the front of the header, which is divided into three chambers by longitudinal and transverse ribs.

The lower header is U-shaped in section, divided into three chambers by transverse ribs, the steam-pipe flange opening into the back chambers.

The headers are each open on the face, which is closed by a flange plate jointed to the header by bolts. Tubes 1¼ inches in diameter, No. 13 B. W. G. thick, are expanded into the flange plates, there being in the design shown 256 of these tubes in all.

The steam passes from the dry pipe to the upper chambers at the front of the upper headers, thence through the tubes to the front chamber of the lower headers and back through other tubes to the lower chamber of the upper header, thence to the middle chamber of the lower header, back to the upper header and thence to the rear chamber in the lower header, from which the steam connection leads to the cylinders. A steel plate partition within the tubes causes the gases issuing from the flue sheet to transverse the superheater tubes on their way to the stack, in order to obtain as much benefit as possible from the heat they contain.

This arrangement is evidently somewhat similar to the "Schmidt" smoke-box superheater, with the exception that the large flue leading from the firebox to the front end, which in Schmidt's design enabled a high degree of superheat to be obtained, has been omitted, and consequently the only heat available for superheating the steam is that contained in the gases after leaving the evaporating tubes.

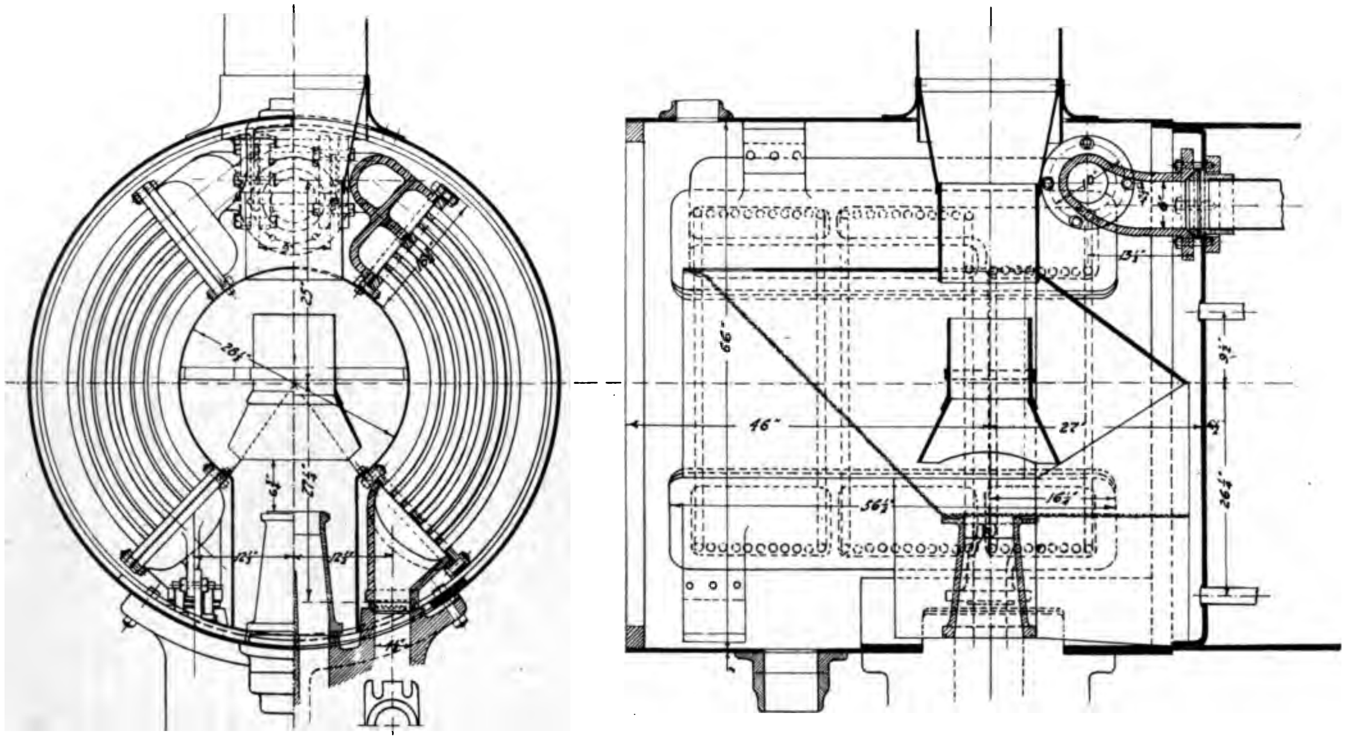


FIG. 1.— Vauclain Superheater.

The Baldwin Locomotive Works have furnished particulars of a test on this superheater conducted on the Chicago, Rock Island & Pacific Railway. The engine tested was a consolidation weighing 237,000 pounds, of which 210,000 pounds was on the drivers, and the principal dimensions as follows:

Cylinders	22 by 28 inches.
Valves	Slide balance.
Boiler, type	Straight.
Boiler, diameter	80 inches.
Boiler, pressure per square inch	163 pounds.
Firebox, length	120 inches.
Firebox, width	72¼ inches.
Heating surface, firebox	179 square feet.
Heating surface, tubes	3,658 square feet.
Heating surface, total	3,837 square feet.
Driving wheels	63 inches.

The test consisted of six runs on the Illinois Division between Blue Island and Silvis, a distance of 158 miles, and six on the El Paso Division between Delhart and Tucumari, a distance of 93½ miles. The general averages of the results obtained were as follows:

GENERAL AVERAGES.

	Illinois Div.	El Paso Div.
Number of cars	45 loaded–25 light.	37 loaded–21 light.
Weight of train exclusive of weight of engine and tender	2,327.0 tons.	1,833.4 tons.
Number of stops	14.7.	3.8.
Time consumed in stops	3 hrs. 16 mins.	1 hr. 33 mins.
Total time of run	12 hrs. 57 mins.	6 hrs. 29 mins.
Speed	16.1 M. P. H.	15.5 M. P. H.
Indicated horse-power	821.5.	891.6.
Weight of coal (losses subtracted)	33,987.0 lbs.	15,752.6 lbs.
Weight of coal per indicated horse-power per hour	4.23 lbs.	3.86 lbs.
Weight of coal per ton mile	.091 lbs.	.119 lbs.
Weight of water (losses subtracted)	217,706.3 lbs.	97,267.7 lbs.
Weight of water per indicated horse-power hour	27.5 lbs.	22.6 lbs.
Weight of water per ton mile	.597 lbs.	.721 lbs.
Equivalent evaporation	7.86 lbs.	7.54 lbs.
Superheat (from initial pressure of cards)	48.8° F.	56.44° F.
Superheat (from boiler pressure)	24.63° F.	33.20° F.
Temperature of steam chest	386.3° F.	403.6° F.
Boiler pressure	154.4 lbs.	159.8 lbs.
Tractive effort	21,375.0 lbs.	24,404.7 lbs.
Length of run	157.0 miles.	74.5 miles.
Coal per square foot of grate surface per hour	57.6 lbs.	54.9 lbs.

During the first two runs on the Illinois Division the temperature of the front-end gases in front and back of the superheater were shown to be 534° and 635° F., showing a drop of 101° in passing through the superheater. An interesting comparison was also made by taking the temperatures of the steam in the valve chest of a simple consolidation, which averaged 24° below that corresponding to saturated steam at the boiler pressure, so that the superheater, which showed an average temperature in the steam chest of from 25° to 33° above that corresponding to the boiler pressure, may be assumed to have raised the temperature of the steam 50° to 60°.

No comparison was attempted on these tests, but the Baldwin Locomotive Works conclude from the results obtained in a test of a balanced compound and simple engine in passenger service, and from the results of the tests at St. Louis, that a locomotive of this type equipped with a superheater will give a saving of fifteen per cent in water consumption and eleven per cent in fuel consumption over a similar simple expansion engine. An interesting comparison made during the test was the increase in tonnage that could be handled by the superheater in proportion to the simple engine, and the absence of water in the cylinders, resulting in decreased trouble with the rod packing. No trouble was experienced in the lubrication of the balanced slide valves with the ordinary sight feed lubricator.

With the exception of the more extended application of the "Vauclain" superheater during the past year, evidently but little interest has been manifested in the system, and yet the replies from these roads on which superheater engines have been in service do not condemn them. The Great Northern Ry., which has one passenger and one freight engine equipped with the "Schmidt" smoke-tube superheater, report two coal tests between the superheater engines and simple engines of practically identical construction.

In passenger service a test on the Kalispell Division showed a saving of 13 per cent in water and 14½ per cent in coal per car mile, while in freight service on the Willmar Division the saving was 30½ per cent in water and 28½ per cent in coal per ton mile, the coal figures being 137½ for the simple and 98 pounds for the superheaters per 1,000 ton miles, both very satisfactory figures for prairie type engines in freight service on an undulating road. They also report a comparison for nine months between a superheater freight engine and a similar simple engine, showing 137 pounds of coal per 1,000 ton miles for the superheater against 171 for the simple, and a cost for repairs of 4 cents per mile against 3.87 cents, a reduction in the coal consumption of 20 per cent with practically the same cost of repairs.

The Boston & Maine R. R. reports on one passenger engine equipped with the "Cole" superheater, that while the original arrangement gave them considerable trouble from leaking and from breakage of the super-

heater pipes near the header castings, when the engine was in good condition, it has given excellent service, and they are taking steps to substitute improved details. They favor further improvement until better results are obtained rather than the abandonment of superheating.

The Chicago & North-Western Ry. reports with reference to one passenger engine with the original "Cole" superheater, which originally gave trouble from header joints leaking, that by the substitution of ground header joints this trouble has been overcome, and states that the results have been very satisfactory the last twelve months.

The New York Central reports on one passenger engine equipped with the "Cole" superheater, a slight reduction in the coal consumption but no conclusion.

The Soo Line reports on one freight engine equipped with the original "Cole" superheater, that they have experienced no trouble except with leaks in the header connections, and while they can not give accurate figures showing consumption of coal, there is evidently a saving, and the engine handles a train better than other engines.

The Lake Shore & Michigan Southern Ry. reports on two passenger engines, one equipped with the original "Cole" and the other with the "Vaughan-Horsey" superheater, that no further tests have been made. They have experienced difficulty in their operation as follows:

1. The lubrication. This was first attempted with the forced feed lubricator, and afterward the ordinary sight-feed lubricator was found to give entire satisfaction.

2. On the "Vaughan-Horsey" superheater the top header broke due to faulty design, which has been overcome by changes in the cross section from square to round.

3. A number of the superheater tubes have cracked, but no remedy has been suggested.

Their conclusion is that the superheater passenger engines have on the whole been satisfactory, and that while certain defects have developed, they are not of a nature that presents any serious difficulty. The engines have proved distinctly superior to simple engines of corresponding types both in economy in fuel and their capacity for handling their trains. They consider superheating a very promising improvement and intend to apply it to a considerably greater extent.

The Canadian Pacific Railway, which, as this report states, has a large number of superheater engines in service, is operated in two systems, the Lines East and West of Fort William respectively, and Mr. Grant Hall, Superintendent of Motive Power of the Lines West, has furnished a report from the Master Mechanics of the three divisions under his charge, having a total of 103 superheater engines at the commencement and 143 at the end of the year. As these statements cover a fairly extended experience with the original "Cole," "Schmidt" and "Vaughan-Horsey" superheaters, extracts from them are quoted as follows:

"We experience trouble in keeping large superheater tubes free and clear from cinders, which, if not done, the benefit of the superheater is lost. I find that the large tube fills up and becomes choked, starting from firebox end extending about two feet in if not kept after and cleaned out regularly; to do this we use a rod, pulling back deposit with a rod with a bent end and then finish up by blowing them through with air. We also find that the small steam pipes get coated with soot, which also prevents us getting full benefit of the heat passing through the tube, which is only partly overcome by repeated blowing out with air.

"The 'Schmidt' type is giving us very little trouble on this Division, perhaps not so noticeable on account of only having one engine of this type. The main top header on this engine, however, has failed twice by cracking around the neck between the header and the flange which bolts to tube sheet.

"The jointing arrangement small superheater pipes has not given us any trouble whatever from leaking or slackening back, which is frequent with other types.

"The 'Cole' type is a constant trouble from leakage at joints where small headers bolt to main header and can not be maintained tight for any length of time. In tightening them up, which is frequently done, the studs, which were enlarged from ¾ to ⅞ inch, are strained, broken and pulled out from main header. When leaking, the flat face on main header as well as the grooved bed in the small headers are cut by steam leaks, necessitating plugging, etc., making it very costly to maintain, not saying anything about holding engine out of service or extra fuel consumption.

"The 'Vaughan-Horsey' type causes trouble by the union joints leaking, caused by nuts slackening off them where jointed to main header, and have to be opened up as often as business will permit and gone over to avoid failures; this being the only trouble we have with this type outside of the returns burning out occasionally, which is equal on all types."

"I am in favor of superheated steam in both passenger and freight service, and consider that we get good results when the arrangement is working satisfactorily and free from leaks. The system should be improved on to lessen the maintenance work, and the question of lubrication most thoroughly gone into with a view of reducing the number of piston and valve rings that are being used.

"With the quality of the oil we are using we find it necessary to renew piston rings every four or five weeks and the valve rings every two months. When piston rings are removed, if not broken, they are worn down to about ⅜ inch thick.

"Have had very little difficulty with respect to superheater tubes stopping up, but it is absolutely necessary that the damper in smokebox be kept in working order.

"With the 'Schmidt' superheaters we experience considerable difficulty in keeping flange joints tight where bolted on header. Have had

one header broken off close outside of flange where bolted on to round head. With the 'Vaughan-Horsey' type we have quite a lot of trouble with the brass ring nut at connections, but using the mild steel nut, I think, will overcome this to a great extent.

"My experience with superheated steam in freight service is satisfactory; have no engines in passenger service equipped with superheated steam.

"In regard to the superheater tubes blocking up in the smoke tube class. We have had some difficulty in keeping the smoke tube clean, and the only way to get good results is to blow them out each trip with air; doing so we have been able to keep them in good condition.

"We have had considerable trouble with the piston and valve rings of the superheater type. This trouble has been eliminated to a large extent by making a more rigid examination of rings and feed attachments to valves and cylinders, also by making a perfect fit of new rings when applied to piston. Another important feature toward the maintenance is the superheater dampers and their attachments. To keep these in working condition it is necessary to inspect them thoroughly every week, which will prevent any trouble from defective dampers, pistons on brackets. The worst feature is the possibility of engine failures on account of superheater pipes bursting and leaking; they give no warning and it is impossible to detect them before giving out.

"In connection with superheaters in freight service, the only difficulty was in the large tubes leaking badly, making it necessary to expand them every round trip. In passenger service I consider them very satisfactory, both in efficiency for this class of work and for the light maintenance of same."

Mr. Hall has also written a general statement of his experience from which the following are extracts:

"We find that the superheater tubes plug up to a certain extent, but we overcome this by blowing out with air. The 'Cole' type only has given us trouble maintaining header joints. In passing I might say, for your information, that the 'Cole' superheater has given us so much trouble in this respect that I would not recommend its use. We have had very little trouble with the 'Schmidt' type, the principal trouble being one that can be overcome, namely, the cracking of the superheater header through the neck. The only difficulty that has been experienced with the 'Vaughan-Horsey' has been the slackening off of the nuts coupling up the superheater pipe to the header; this type of superheater is an easy proposition to maintain.

"In regard to lubrication. We have had nothing in the shape of forced feed that gave satisfaction, and have none now in service, being replaced entirely by sight-feed lubrication. It is not necessary that we have separate cylinder connections, but I do consider it necessary to have connection to each end of the valve bushing when using superheated steam. My experi-

ence with superheated steam in both passenger and freight service is satisfactory."

On the Lines East of the Canadian Pacific for which the Chairman of the Committee is reporting, practically the only superheater in use is the "Vaughan-Horsey," as those with the "Schmidt" are on Lines West and most of the original "Cole" have been converted.

The important question during the past year has not been one of economy but of maintenance, not with respect to cost, for in that respect the addition of a superheater is not noticeable, but with respect to reliability. Engine failures are annoying and expensive, and no device can be a permanent success which introduces them to any extent. The important troubles that have developed during the last year have been three in number:

1. Leakage at the union connections between the superheater pipes and the header due to nuts slackening off.
2. Bursting and splitting of superheater pipes.
3. Breakage of superheater header.

Leakage at the union connections was at first caused by brass nuts having been used, and with the change to steel nuts it appeared to have ceased. Considerable trouble has, however, been experienced with the steel nuts, although not universally, as on some divisions it is practically nil, but in many cases the nut has slacked off entirely, causing a complete and annoying failure. The reasons appear to be poor workmanship and insufficient strength of the nuts. With stronger nuts and proper workmanship, both of which can be arranged for, this trouble should be overcome, but it has been decided to apply lock nuts of which several designs are now on trial, which will without a doubt overcome the difficulty; and while a monthly inspection is required, failures from this cause will be avoided.

Bursting and splitting of superheater pipes, while not frequent, can be avoided only by proper maintenance of the dampers. This defect does not occur frequently, and is no doubt partly due to insufficient care having been taken in putting up the pipes to the correct lengths.

Breaking of superheater headers, while not frequent, has occurred several times, but can be stated definitely to be a defect in design.

Only top headers have broken and these all in practically the same place, at the junction of the steam-pipe flange with the header. By changing the form and insuring a stronger metal, there is little doubt of this trouble being overcome.

The number of failures from the above causes have not on the whole been excessive. From April 1, 1907, to January 31, 1908, thirty-nine superheater engines in passenger service made a total of 1,382,820 miles with a total of fifteen failures. Of these nine were due to joints leaking, four to pipes bursting and two to headers breaking. The number of miles per engine failure was therefore 92,188, and as eleven of these failures are

from causes that can be overcome it is evident that when this is done the unavoidable failures are not a serious drawback.

Figures are not available giving the failures in freight service with any degree of accuracy, as if the records were taken as they stand they would show so small a number of failures that their unreliability would be evident, but those in passenger service are reasonably correct.

So far as the cost of repairs is concerned the addition of a superheater does not appear to be noticeable. The superheater itself certainly costs something to maintain, as do the necessary inspection of its parts, but the net result is, so far as the records on the Canadian Pacific Ry. are concerned, in favor of the superheater as against any other class of engines, and there is no evidence whatever of increased cost.

While discussing the difficulties introduced by the application of superheaters there are certain advantages which to a large extent offset them. Where simple engines have been converted, they have shown an increase in capacity that may be roughly estimated at about ten per cent. They run more freely and are decidedly easier on their fire, allowing an inferior grade of coal to be burned with less difficulty; to an extent which caused a superheater passenger engine to handle trains without loss of time when similar simple engine failed to do so. There is also a notable absence in superheaters of the trouble caused by water, and on the whole, providing the difficulties mentioned are overcome, it is a close question whether superheater engines will not average less failures than a corresponding number of simple engines, and they will certainly handle heavier trains and make time. Where coal is expensive and the question is one of the adoption of a compound or a superheater, there is no doubt that the latter will give greater economy, with a smaller cost for repairs and less trouble.

The results in fuel consumption appear to confirm the statements made in the last report, namely, ten to fifteen per cent in freight service and fifteen to twenty per cent in passenger service. It does not appear necessary to present these figures in detail, as this has been done in previous years, but the results for July to December, inclusive, have been gone over by sections and months, those cases being selected in which sufficient work was performed by the two classes of engines being compared to render the results reasonably reliable.

The equivalent coal is the coal which the class of engine shown would have burned had its consumption per ton mile been equal to that of the class taken as the basis of comparison, while its relative consumption is the proportion of the actual to the equivalent coal. As these quantities are calculated month by month and the traffic and weather conditions thus equalized, this method is comparatively accurate.

The comparison of simple consolidation engines class M-4b with similar "Vaughan-Horsey" superheaters is shown in Table 1, from which the average consumption of the simple engines works out at 113½ per cent of that of the superheaters.

The consumption of compound ten-wheel freight engines D-9 and "Cole" superheaters, D-10c with "Vaughan-Horsey" superheaters, is shown in Table 2, from which the average consumption of the compound engines works out at 100 per cent and that of the "Cole" superheater at 107 per cent of that of the "Vaughan-Horsey" superheater.

Table 3 shows the comparison of Pacific type superheater engines, Class G-2, and of ten-wheel superheater, E-5g with ten-wheel simple engines, Class E-5. The ten-wheel superheaters are engines converted from simples and are otherwise similar. From this table the saving in fuel on the converted engine works out at 21 per cent and that of the Pacific type at 22½ per cent on Lines East, but this figure is subject to the larger engine doing more work for the same weight of train or handling heavier trains, although only certain sections have been included where this variation is a minimum. The results on the Brandon & Swift Current sections are remarkable in view of the large amount of coal burned, and show, with a total of 5,250 tons, a saving of about 35 per cent.

TABLE 1.

SECTION.	Class.	Coal.		Relative Consumption.
		Actual.	Equivalent.	
				Per Cent.
Farnham	M-4b	2,999	2,683	112
Newport	"	1,121	885	127
Havelock	"	86	80	107½
Toronto	"	2,385	2,162	108
London	"	618	546	113
North Bay	"	1,204	1,052	114
All	"	8,413	7,408	113½

TABLE 2.

Ignace	D-9	885	862	103
Kenora	"	781	781	100
Brandon	"	1,079	1,110	97½
All	"	2,745	2,753	100
Ignace	D-10c	2,030	1,920	106
Kenora	"	9,012	8,288	109
Winnipeg	"	15,498	15,537	99½
All	"	27,540	25,745	107

TABLE 3.

North Bay	G-2	246	177	72
Chapleau	"	364.	270	74
White River..........	"	363	308	83
All..................	"	973	755	77½
Brandon.............	"	2,753	4,169	66
Swift Current.........	"	2,496	3,890	64
North Bay	E-5g	555	704	79
Smith's Falls.........	"	990	1,281	77

The replies show that the question of lubrication appears to have been settled by all roads resorting to the sight-feed lubricator.

Two roads report satisfactory results with a single central connection to the valve chest as on ordinary simple engines, but the majority are using the separate cylinder connection with either one central or two separate connections to the valve chest.

On the Canadian Pacific some engines are running with one central connection to the valve chest and no cylinder connection, but the preferred arrangement is the separate connection to the cylinders with one feed to the valve chest split to feed to both ends. The cylinder connection feed is generally cut down to a very small amount when running and most of the oil fed through the valves, but the majority of the men prefer to have it in case it is required.

Your committee does not feel that it is called on to present any conclusions or recommendations on this subject, and prefer to simply state the facts so far as they have been able to obtain them for your consideration.

H. H. VAUGHAN, Chairman,
L. G. PARISH,
R. D. HAWKINS,
Committee.

MONTREAL, CAN., May 15, 1908.

MR. VAUGHAN: In passenger service I wish to modify the figures in Table 3, in which the G-2 engine superheaters are shown as having burned sixty-six and sixty-four per cent respectively, of the coal used by the simple engines. After getting those figures together and going into it, we find that the simple engines have been used on lighter trains and faster trains than the superheaters on an average, and I consider that a good deal of that saving is due to that fact; but I do consider that the figures for the E-5g and G-2 engines, on the first four lines of the G-2

engines, showing a saving of twenty-one and twenty-two and one-half per cent, are as accurate as we could get them from our road figures.

I would like to say this about the superheater question. We are up against a rather peculiar condition. It is a very general thing for devices that show a substantial saving on the test plant not to show the same saving when applied to the road. Our figures for these six months, which I really consider are figures that we get right along, show a greater saving on the road than the test plant figures have shown, and I simply must confess that I do not understand it, unless it is that the superheater engines are, as a general thing, preferred by the men running them and get a little better attention or get steadier men on them. I can see no other reason for that. To save twenty-one to twenty-two per cent in regular service, coal chute figures, must mean a saving of thirty per cent, at least, while the engine is running, when you consider the amount of coal shoveled into an engine before she starts, and other features.

Outside of the German figures which have been given by Messrs. Harvey & Schmidt, and which I have always regarded as exaggerated, we have practically no experimental data to confirm any such saving. At the same time, I conscientiously believe we are getting it, because we have too many engines,— we do not keep special men on the superheaters any more; the first engine or two we got, when we showed thirty-five per cent saving, we did. That is, the saving was largely gained by the men, but we have to-day about seventy superheater passenger engines, running in and out, getting all sorts of crews and men and nobody paying special attention to them any more, with four or five hundred engines in service, and there is no talk about the superheater being petted; our experience is very satisfactory in some ways. The General Manager of our lines West the other day, when I was discussing the advantage of getting some more simple engines with which to make better comparison figures, told me that we could send him compounds or superheaters, but he would not have simples any more. He did not regard the idea of building an engine in order to get comparative figures for our information as a very satisfactory idea; he was perfectly satis-

sixty or seventy thousand miles, but in passenger service, where the superheat seems to be high, and the work is more continuous, we find that about six weeks is about the average length of a piston packing ring. It is not due, I believe, to defect in lubrication. Mr. Hall says lubrication wants to be studied out, but we have got a good coat of oil on the cylinder and I believe we will get better results by paying attention to our iron, and perhaps paying attention to a particular kind of oil for superheaters, as we have been running with the regular valve oil. I notice that the Germans find that any oil that makes a sticky surface will wear very quickly. The Germans, by getting an oil that leaves a cleaner surface, seem to have obtained better results. Passenger service is the thing that I think, without doubt, superheat is applicable to. That is my feeling in the matter. I said last year that in a case of freight service you may, and passenger service you must. We took an engine and applied a superheater to it, and put it in with other engines of the same class. We had an epidemic of poor coal last fall, and the superheater engine was the only one out of six that did not lose time. That engine was able to burn the coal where the simple engines could not stand it. We also found that the size of the nozzle is of very much less importance. One of our master mechanics reported to me the other day that he could not find any difference in the running of the engine when the exhaust nozzle was reduced away down. If you will consider that we are running with the same sized nozzle on the superheated as we are on the simple, and using twenty per cent less steam, you will see why the engines are very free-running engines. Our men consider them better on an eight or nine car train. They all say the superheater is far better than the simple. I believe, myself, that our figures are about right on the twenty per cent saving and that is a most important thing in passenger firing. We have case after case where firing has been pretty heavy on passenger trains, and after the use of the superheater the men say the firing is a cinch. You ask for coal records. We have given a good many that are very low figures, I consider. I am always rather averse to quoting coal figures because I know some member will quote a coal record that is thirty per cent less, but I do believe there is a good deal of saving.

THE PRESIDENT: Anything further on this subject?

MR. VAUGHAN: It was my fault for not reading everything. The report shows the comparison of simple consolidated engines, Class M-4b with similar "Vaughan-Horsey" superheaters as shown in table one. There the simple is compared with the superheater because we have so many more superheaters than we have simple. It is always wise to compare with the engine you have a lot of because their figure is an average one. In table two the 10-wheel compound and the Cole superheater is compared with the "Vaughan-Horsey" superheater because there again we have more of the compound. In table three they are compared with the simples because we have more of the simples.

MR. SQUIRE: Then the superheater becomes the basis of comparison?

MR. VAUGHAN: No, in the first two it is, but in the third the simple is the basis in order to take the engine we have the most of as the basis of comparison.

MR. MUHLFELD: The committee has given us some very valuable information, and Mr. Vaughan's experience under climatic conditions which are unfavorable for superheat is especially interesting, but there are a couple of points which I think very important that have been omitted. One of those is the degrees of superheat we can make use of with economy, and the other whether we can afford to use the live products of combustion, or the waste gases or a combination of the two to produce superheat. I think there is no doubt that a considerable degree of efficiency can be obtained from highly superheated steam, providing the heat can be properly utilized. However, I believe in a simple cylinder locomotive that the greatest efficiency will be secured when the superheat is just sufficient to prevent losses due to internal condensation and friction of steam on account of expansion in the cylinders and when all thermal heat is converted into work and no heat except that normally due to pressure is rejected at the exhaust. If we use the live products of combustion to produce superheat, and are then unable to utilize all of that heat it seems to me we are coming to the point where the greatest efficiency will not result, and for that reason I bring up the point as to whether we should confine the superheat to what can be obtained from the waste gases or go further and

utilize the live products of combustion to obtain superheat in preference to utilizing such live products of combustion to obtain saturated steam. I do not believe that highly superheated steam can produce the greatest efficiency in the short cylinders of a simple cylinder locomotive where it is only subjected to from one to four expansions, for the reason that it requires ten to twelve expansions to convert all its heat into work, and would, therefore, exhaust a considerable amount of energy to the atmosphere. I am also of the opinion that the tendency of superheated steam, to absorb all moisture in lubricants, will result in the necessity for more attention to valves and pistons, and that there will be greater losses due to convection, radiation and steam leakage. However, with compound locomotives — I have in mind particularly the Mallet type — where a greater ratio of expansion can be obtained, I believe that superheat in combination with high pressure may be used to good advantage providing the superheat is just sufficient to prevent losses due to internal condensation and friction of steam and when all thermal heat is converted into work, and none except that normally due to pressure is rejected at exhaust.

I haven't seen anything positive except in relation to foreign locomotive practice, where they advocate extremely high superheat. It seems to me this is a very important, and a very live subject, as superheat will, no doubt, increase efficiency and give fuel economy, but I would suggest and will make a motion to the effect that the committee be continued and that it be requested in its next report to give us some information pertaining to the use of the live products and the waste products of combustion to produce superheat, and the degrees of superheat that should be resorted to to obtain the greatest efficiency in simple and compound cylinder locomotives. The committee has given us some good information and is in a position to carry on and complete its investigations in a very thorough manner.

Mr. Forsyth: Mr. Muhlfeld has brought up the question of economy of highly heated steam, and as I understand it, that has been thoroughly threshed out in Germany. There they favor highly superheated steam and obtain a good economy from it; and further, the whole theoretical consideration of this subject

in regard to temperature of superheated steam was fully treated in reports to this Association by Mr. Vaughan in previous years. I think he will sustain me in that statement, and that the further consideration of that point is not necessary.

Mr. Muhlfeld: If we were constructing locomotives, in view of the necessity for reducing transportation expenses, and the fuel item being a very large one, we would like to have some data that would be the result of actual performance in this country, and not under the conditions that obtain in foreign countries, on which to base our recommendations for the use of superheat, and which will give us something with which we can substantiate our claims. It is very important to get some data in line with the suggestion made, that is, as to how far we should go in the use of the live products of combustion, whether we should confine ourselves to the waste products, or make a combination of the two in order to obtain a degree of superheat which, from the standpoint of maintenance and operation, will give us the proper degree of efficiency. There is no question about superheat giving a certain amount of efficiency; but how far should we go with it? I do not think that we can use the data that have been given us from foreign practice. In simple engines you get from three to four expansions, and in compound engines from ten to twelve. How high should we superheat steam so that when we exhaust that steam we do not exhaust heat that could better be used in producing saturated steam rather than superheated steam. I think this is a very important point, and I have noticed in reading the reports pertaining to superheater engines of different types, that some use the live products of combustion and some the waste products, or a combination of the two, and there is a wide range. Some experts advocate 50, some 100 and others 150 degrees of superheat. I think it is a very important question as to how far we should go, and it deserves thorough study.

Mr. A. W. Gibbs (Penna. R. R.): I would like to ask the members of the committee whether they have observed any change in iron castings, such as valve chests and bushings, where subjected to this superheat. I ask this because my attention has been called to some of the cast-iron fittings in our power stations where superheated steam is used. These fittings have increased

very materially in dimensions, in some cases. In one case, some long cast-iron crosses have increased over two per cent in length. I have been wondering whether anything of the sort has been noticed in the cylinders and other connections on locomotives using superheated steam. My understanding is that what has been done, is to take the regular engine and put hot steam into it, making no other change. Another point on which I would like to have information, is whether the effect of superheating materially improves the performance of compound locomotives, either when used to pre-heat the steam or to reheat it between the cylinders. I think that anyone who has ever handled one of the White steamers will have noticed that you may have very high steam pressure and very sluggish action because the steam is moist, while again with comparatively low pressure, but a very high degree of superheat, there is a most surprisingly good performance. I wish to get a little line on this subject, with the idea of ascertaining the benefit of superheated steam for passenger locomotives in improving the speed characteristics. As for the question of warping, if it does exist I would like to see whether any attempt has been made to connect it with the question of the composition of the iron.

MR. VAUGHAN: I would like to answer these gentlemen now, — first, Mr. Muhlfeld. In my paper in 1905, I went into the question you raised very thoroughly, and I submitted a proof then that while you did reject unused heat, at the same time it is still more economical to reject that heat than it is to be without it. In the same way, assuming a certain number of expansions, with a boiler pressure of 100 pounds you are not rejecting any heat that you can avoid. Still it is more economical to raise that boiler pressure to 200 pounds and reject your steam at 140 than it is to use 100 pounds and reject it at a lower pressure with the same number of expansions.

Some years ago in connection with another gentleman, I prepared a report, based on the theta phi diagram, which clearly demonstrated that even though heat is wasted it is in the nature of unavoidable waste, and it is still more economical to start with higher superheat than with lower. I was, therefore, convinced that we need not be afraid of rejecting superheat in the exhaust.

I divided our gain from superheat into two items. The first was the action due to avoidance of cylinder condensation. The second that due to increase in volume. When not working expansively the latter still remains. If you will look into that paper you will find that question was taken up carefully. As far as degrees of superheat go, in practice we have had a lot of engines that gave us from 20 to 30 degrees of superheat and we pulled the heaters out of them because there was not enough benefit to worry about. We could see so little difference between them and simple engines. At first there was a benefit, but after the tubes became coated from the soot I did not consider that there was enough benefit to warrant our continuing the use of low superheat. We have in freight service now from 100 to 150 degrees of superheat and we have engines,— our regular engine I think is a 66 front end, both with twenty-two tubes, and with twenty-four tubes, giving us eighty-eight or ninety-six superheated pipes. Now my opinion is that the twenty-two tubes are slightly superior to the twenty-four. I believe that if all these tubes were kept properly cleaned out we would get better service from the twenty-four, but there is a little too much evaporating surface to be cut out, and I rather prefer the twenty-two-tube engine. We have one hundred engines of each sort, and have watched them a little, and I could not tell you which of those two engines is the more economical, but I rather favor myself not going any farther with superheat than is necessary to obtain the best results. I think that would be good practice. Personally I do not wish to take any position against the Baldwin superheater, but I think if you are going into superheating you might as well obtain a reasonable amount of superheat, and I believe the Germans have been on the right track in going to high superheat.

I have not struck any trouble with warping, Mr. Gibbs, that I am aware of. As a matter of fact, we have never measured our castings for it; but you are perfectly correct. We have not worried about special construction at all. Our engine was an ordinary plain American simple engine, and we did not need to change it at all. You do need a very close, hard iron for packing rings; if you go to an iron with high phosphorus in it it will wear very rapidly. The packing rings have run as much as

sixty or seventy thousand miles, but in passenger service, where the superheat seems to be high, and the work is more continuous, we find that about six weeks is about the average length of a piston packing ring. It is not due, I believe, to defect in lubrication. Mr. Hall says lubrication wants to be studied out, but we have got a good coat of oil on the cylinder and I believe we will get better results by paying attention to our iron, and perhaps paying attention to a particular kind of oil for superheaters, as we have been running with the regular valve oil. I notice that the Germans find that any oil that makes a sticky surface will wear very quickly. The Germans, by getting an oil that leaves a cleaner surface, seem to have obtained better results. Passenger service is the thing that I think, without doubt, superheat is applicable to. That is my feeling in the matter. I said last year that in a case of freight service you may, and passenger service you must. We took an engine and applied a superheater to it, and put it in with other engines of the same class. We had an epidemic of poor coal last fall, and the superheater engine was the only one out of six that did not lose time. That engine was able to burn the coal where the simple engines could not stand it. We also found that the size of the nozzle is of very much less importance. One of our master mechanics reported to me the other day that he could not find any difference in the running of the engine when the exhaust nozzle was reduced away down. If you will consider that we are running with the same sized nozzle on the superheated as we are on the simple, and using twenty per cent less steam, you will see why the engines are very free-running engines. Our men consider them better on an eight or nine car train. They all say the superheater is far better than the simple. I believe, myself, that our figures are about right on the twenty per cent saving and that is a most important thing in passenger firing. We have case after case where firing has been pretty heavy on passenger trains, and after the use of the superheater the men say the firing is a cinch. You ask for coal records. We have given a good many that are very low figures, I consider. I am always rather averse to quoting coal figures because I know some member will quote a coal record that is thirty per cent less, but I do believe there is a good deal of saving.

THE PRESIDENT: Anything further on this subject?

Mr. Forsyth: Mr. Vaughan has explained to us the advantage of high temperature superheat so far as the coal economy is concerned. I think the report gives tests showing the advantages of the superheater in bad-water districts.

Mr. Vauclain: I am very glad to hear Mr. Vaughan remark that he did not take very much stock in low superheat as acquired by the Baldwin superheater. I have no doubt that he would be very glad to know that I do not take very much stock in the high superheat. The honors are equal and no harm done. For twelve or thirteen years I have been interested in superheaters. I have a friend on the other side of the water, Herr Gerbe, who is an ardent advocate of highly superheated steam, and he has undertaken upon two or three occasions to sell outright to the Baldwin Locomotive Works all the patents that Mr. Schmidt has or will have on the smoke tube or highly superheated steam appliances. I have always felt that highly superheated steam was not what we wanted in this country, but that we wanted a superheated steam superheated sufficiently to overcome all the loss of the single expansion locomotive, and at the same time enable us to go back to a normal boiler pressure of 160 pounds. If we could do this, we would overcome the necessity of the compound locomotive, and the necessity of any special appliance or special metal in the construction of our locomotives for the highly superheated steam, and we would be able, if possible, to produce a locomotive that would require even less attention than is now accorded the single-expansion locomotive. And it was to this end that we did some thinking. I felt that if we could obtain anywhere from four hundred to seven hundred feet of heating surface in a smoke-box superheater that could be applied to any locomotive existing without any boiler alterations in lieu of the ordinary cast-iron steam pipe, we could obtain enough superheat by this process to enable us to accomplish all we wanted to with superheated steam, and at the same time give the average American railway a machine that could come in and go out every day in the week without any attention, and to make the maximum number of train miles per month with any locomotive they might have in service. After considerable persuasion, Mr. Kendrick, of the Santa Fe Road, allowed me to try the experiment on him.

We were building a large number of tandem compound locomotives and I persuaded him to allow me to build a smoke-box superheater, allowing me to send along with the engine all the parts necessary to complete it as a tandem compound locomotive. We took off the high pressure cylinders and put them in the tender, a very good place for them. We took out the cast-iron steam pipes and put in a smoke-box superheater to replace them. We coupled up the steam pipes to the valve chest of the low pressure cylinder with a cast-iron pipe running around in front, and took out the high pressure valve so as to use the engine as a low-pressure single-expansion locomotive. The cylinder was 32 by 32 and the working pressure was 220 pounds. We reduced it, using the ordinary method of calculation, to 130 pounds. We thought we would make an experiment in the matter. Now this locomotive went into service and did so well that nobody took the trouble to inquire what might be in the smoke box, but they found that the pressure could gradually be increased and it was increased until finally the locomotive carried 160 pounds. The reason for that is this, that where the usual ratio by reducing to 130 pounds was about 4 3-10, it was found that this locomotive could be safely worked down to a ratio below four; and I have in my office at home a record of this engine which has only 237,000 pounds on drivers, giving a drawbar pull continuously of 68,000 pounds working on sand. The same thing that was found on this locomotive was found in Germany, that in order to get the very best results from superheated steam, very large-sized cylinders must be used in proportion to the weight on drivers, so that a greater number of expansions can be obtained from the steam than that ordinarily considered in the construction of our single-expansion engines, and personally I care to do nothing further in the way of superheat. I prefer to let this one engine solve the problem as to whether there really was any advantage in low superheated steam; and Mr. Vaughan may be, perhaps, pleased to know that there evidently has been, because we have been called upon to build a very large number of these same smoke-box superheaters, not only for the Santa Fe road, on which we tried the experiment, but by other roads who received their information not from us, but by a visit to those roads where these locomotives

are running, and seeing the work they are able to accomplish with them.

I had in view another idea when this locomotive was built and that was to determine whether such an engine would be as economical in road service as the best compound engine that we were turning out, and we have had it proven to us — we have not proven it to anybody else, but we have it proven to us most clearly that we can obtain the same economy from a low superheated locomotive carrying a low boiler pressure of 160 pounds as we can with compound locomotives carrying 220 pounds. In addition to this relative economy we obtained another thing: we obtain anywhere from thirty to fifty per cent additional engine miles from that engine in a given time. In other words, there is nothing to get out of order. There is less to get out of order about a locomotive of this kind than there is about any single-expansion locomotive carrying high-pressure steam, or any compound locomotive carrying low-pressure steam. I think that every one of you will agree with me that a compound locomotive will require more attention at terminals than a single-expansion locomotive, and that a single-expansion locomotive carrying high boiler pressure will also require more attention at the terminal than a single-expansion engine carrying low boiler pressure. So therefore we get in a low boiler pressure low superheated locomotive the opportunity to keep that locomotive in continuous service much better than we do with any other type of locomotive that we build. We believe in it, and we believe in it firmly, because it has been proven to us, not through any machinery of our own, but through the machinery of those who have, rather against their will, tried these things and tried them out. We must, of course, look upon all these things from a commercial point of view as well as from a scientific point of view. It makes very little difference what you might be able to produce and bring out if the interest in this matter is such that no one cares to purchase it. We feel that a low superheat device of this kind is a commercial success already, and will be a very much greater success in the future for this reason; that we have in this country probably sixty-five per cent of all our locomotives carrying about two hundred pounds steam pressure. We have a very large

number that are carrying 220 pounds. Some of those have been in service ten years. They all had a good factor of efficiency when they were new, but they have deteriorated somewhat. We think we have a device that will enable any owner of locomotives to change his locomotive and bring that same old locomotive that is ten years old up to the very highest state of perfection and have the factor of safety in it greater than it was when it was originally built.

The President: Is Mr. Foster of the Lake Shore Road in the room? We would like to hear from him.

Mr. O. M. Foster (L. S. & M. S. Ry.): Mr. President, I have not very much to say. Our experience on the Lake Shore with the superheater has been rather limited, but at the same time, quite convincing as to the advantage of superheating. Our use of it has been restricted to two passenger engines of a class of forty-six engines, but they have given us a pretty good opportunity to estimate as to the comparative merits of these engines, simple and the superheater. The application of the superheater to these two engines immediately put them in a class by themselves so far as performance was concerned. It became our practice to use these two engines for the hardest passenger service that this class of engine was assigned to. They happened to be at that time our engines of greatest capacity. Of course it needs no argument to prove that if we put them on the hardest service we did it because they were the better engines. They handled a train better, they made better time, and they handled a bigger train more successfully. We never made any careful test as to comparative economy. In a rough way, however, we think, and our engineers all agree with us, that they show an economy of fifteen or twenty per cent in fuel and water, and this with an increased efficiency in the handling of traffic. Our engineers believe so thoroughly in the superheat that it is quite common to hear them say that they would like to see a superheater put on our later class of passenger engines. We now have a larger class of passenger engine, and it is quite common for the engineers to say that they would like to see the superheater on that engine, that they believe it would make a better locomotive of it. I have no doubt that this is the case, and we are so thor-

oughly convinced of this fact that it has been decided to apply superheaters to some of them.

I made a visit to Montreal last winter for the purpose of seeing what they were doing with the superheater on the Canadian Pacific, at which time I talked with the men immediately in touch with the proposition. I did not go to the head of the department to find out what they were doing, but I went to the roundhouses and to the engineers. I did not hear any complaints from the roundhouse foremen in regard to the question of maintenance at all. There seemed to be a disposition to regard the question of maintenance lightly, to say, "Well, there isn't much to that, we get along with that all right, we don't have any trouble with that." But the engineers,— I did not talk with a great many of them, but I talked with some of the passenger engineers, and they were unanimous in their opinion that the superheat made a distinct improvement in the efficiency of the engine. In fact, one engineer told me of a certain engine which he ran that was unable to make the time on the train to which she was assigned; and he said that after they put the superheater on her she walked right up to the front and was distinctly improved so that she made the time without any trouble and did it with less coal. I did not inquire very much over there as to the economy. Mr. Vaughan has fully explained that. I presume the question that sticks in the minds of most everybody is as to the matter of maintenance. I presume lots of people are convinced that the superheater will be a more efficient engine in service, a more economical engine, but they are afraid of the roundhouse disaster that would follow the general application of superheaters to their engines. Now, as I said, our experience has been limited. You can not tell from one engine what you might run into with forty of them; but our experience has been that the increase in cost of maintenance is inconsiderable, and I believe thoroughly that we could put superheaters onto the same class of engines and experience no particular trouble. We need not fear what may result in the way of additional cost for maintenance or of loss of service. I believe these two engines we have will go right along and make their mileage month in and month out with other engines of that type. There is nothing about these superheaters that necessarily need make the trouble anyway, and

the only trouble that could be experienced would result from inferior workmanship. With good work guaranteed in putting the superheater up I do not believe that it would cause you enough trouble to talk about. You would have a better and a more economical engine.

MR. E. A. MILLER: Mr. President, I understand Mr. Sanderson has gone to considerable trouble and pains to investigate the superheater, and I would be pleased to hear from him.

MR. SANDERSON: Mr. President, the investigations which I have made recently have been very instructive to me, but they were made on a road with which I am not in any wise connected, and I do not believe I am authorized to speak for them, beyond saying that I am a complete convert.

MR. SQUIRE: Mr. President, I believe there is a motion before the house made by Mr. Muhlfeld and seconded by myself.

THE SECREARY: The motion was that the committee be continued and requested to give us more information pertaining to the use of the live products or waste products of combustion.

THE PRESIDENT: Mr. Muhlfeld, do you wish to have that motion stand as you gave it after Mr. Vaughan's explanation?

MR. MUHLFELD: Mr. President, I think from the discussion we have had here that there seems to be some question as to the limit of heat in superheating. The committee has done a great deal of good work and I think we should get the benefit of their further investigations. I would appreciate very much, so far as I am concerned, to have that committee continued.

THE PRESIDENT: Gentlemen, you have heard the motion of Mr. Muhlfeld, and it is now before you.

(The motion was carried.)

(On motion of Mr. Clark, the discussion on the report of the Committee on Superheating was then closed.)

THE PRESIDENT: The next subject before the convention will be "Mallet Compounds," and I will ask Mr. Muhlfeld to come forward and present the report of the committee on that subject.

REPORT OF THE COMMITTEE ON MALLET ARTICULATED COMPOUND STEAM LOCOMOTIVES.

To the Members:

Your committee appointed to report on this subject respectfully submits the following conclusions, which are based on a comparison of the Mallet articulated compound types of steam locomotives now operating on American railways in road and helper freight service with other designs of steam and electric locomotives performing similar work under relative fuel, water and climatic conditions.

FROM A MECHANICAL STANDPOINT.

First: That for the greatest permissible tonnage and speed per train, on lines of considerable gradient and curvature, the Mallet articulated compound types of steam locomotives, either with or without leading and trailing trucks, and ranging in tractive power of from 55,000 to 125,000 pounds, are relatively lower in first cost and from performance to date more efficient and economical in operation and maintenance per unit of tractive power developed.

Second: That the Mallet articulated compound types of steam locomotives enable a practical improvement in the boiler efficiency by means of greater boiler capacity, increased reserve steam and water storage, larger grate area and fire-box and tube heating surface, prolonged passage of the products of combustion through the boiler, quickened circulation of the water in the boiler, heated feed water and reduced rate of draft and combustion.

Third: That the Mallet articulated compound types of steam locomotives give the practical opportunity to improve the engine efficiency by means of relatively greater tractive effort per pound of adhesive weight and from superheated higher initial, reheated receiver and lower terminal working steam pressure due to the greater ratio of expansion that can be obtained in the cylinders as well as through the use of a large intermediate receiver capacity, which is made possible by the four independent cylinders and their supply steam connections.

Fourth: That the Mallet articulated compound types of steam locomotives should have less depreciation, wear and failure of boiler and machinery through increased reserve capacity, reduced pressure of exhaust steam, more flexible wheel base, subdivision of power and stresses over a greater number of frames, cylinders, pistons, axles, crank pins, rods and auxiliary parts; better balancing of the reciprocating and revolving mechanism, more uniform turning moment and less slipping of driving wheels.

FROM A MAINTENANCE OF WAY STANDPOINT.

Fifth: That the Mallet articulated types of steam locomotives having relatively less nonadhesive weight per driving wheel and a more uniform

turning moment with a reduction in unbalanced pressure at the driving wheel and rail contacts, resulting in maximum adhesion, minimum slipping and a distribution of weight over a short rigid combined with a long flexible wheel base, will materially reduce the bridge, tie and rail strains and the tie and rail wear per unit of tractive power developed.

FROM A TRANSPORTATION STANDPOINT.

Sixth: That the Mallet articulated types of steam locomotives either for road or helper freight service can materially increase the capacity of a given piece of track by fewer train movements and less congestion at terminals without increasing the acceleration or running speed above that which is permissible for efficient and economical heavy tonnage train movement, proper working super-elevation of curves, minimum rail wear and the least liability for derailment or accident.

Seventh: That the Mallet articulated compound types of steam locomotives will particularly place the movement of the traffic under the control of fewer persons; lessen the liability for complete disablement and reduce the cost for engine and train crew hire, fuel, water, lubricants, stores, wiping, hostlering and dispatching.

Eighth: That the nonpaying weight in motive power and supplies and the retarded movement and stalling of heavy tonnage trains will be minimized by the Mallet articulated types of steam locomotives, especially through exceptionally long tunnels where the permissible reversing of this type of locomotive will not subject the crew to the gases, smoke and heat from the exhaust.

FROM AN ENGINEERING STANDPOINT.

Ninth: That the use of the Mallet articulated compound types of steam locomotives may permit of maintaining or progressively increasing the average gross tonnage per successive train movement between terminal yards to that which, consistent with the balancing of the motive power, distribution of cars and the accumulation of the traffic on the divisions, might give the desired capacity as well as efficiency and economy in the operation of a single piece of trunk-line track and its terminals without making an expenditure on roadway to increase the weight limit or for a reduction of grade, curvature or distance that would otherwise be necessary to accomplish the same result.

FROM A GENERAL STANDPOINT.

Tenth: That for service where it is essential to increase the tons moved per mile per hour per unit of cost by developing greater tractive power in one locomotive than what can be efficiently and economically produced by a consolidation or similar type and where the use of self-contained motive power, proportion of adhesive to total weight, center of gravity, distribution of weight over driving wheels, driving wheel load, flexibility of driving wheel base, and particularly the first cost, fixed charge, operating expense and reliability of service are elements of

importance, the use of the Mallet articulated compound types of steam locomotives should receive careful consideration.

In arriving at the foregoing conclusions your committee has kept in mind the importance of the steam railroad mechanical engineer to the past and for the future commercial development of the transportation facilities of the country and in the conservation of the natural resources of timber, coal, lignite, oil, natural gas and other fuels which are being rapidly depleted.

Where suitable fuel is lacking or high in cost and water-power is in abundance it is proper and may be economical to utilize that energy which only the climatic conditions of the country will change and conserve the other. Even where inferior grades of fuel are in abundance and can be obtained at reasonable cost it is most undesirable that the past and present wasteful and inefficient uses should be continued and much can be accomplished in this direction by the use of the type of steam locomotive under discussion which can produce relatively more work per unit of fuel consumed.

For general heavy freight service the movement of a given gross tonnage in fewer trains at different speeds of lower resistance is preferable to a greater number of trains at a uniform higher speed of increased resistance. Steam locomotives provide for this in a reliable and flexible combination of power and speed that will meet the varying conditions of weight, class and stops of trains as is necessary for the most efficient utilization of the track and terminal facilities. Although electric locomotive service may be capable of producing comparative hauling capacity in the handling of light and heavy tonnage on a single track by means of its essential and inherent elements of fixed high acceleration and speed, as well as earning power through the medium of the surplus current and certain auxiliary city, terminal and tunnel advantages, still the limitations with respect to the combinations of tractive effort and speed and the large number of systems in an experimental stage from which to arrive at a choice, makes the advisability of such an installation problematical when it is known that steam locomotives under similar conditions can enhance their characteristic self-contained and independent earning power by means of heavy, continuous tractive effort that can be developed for long periods at variable or constant speeds and thereby promote the quickest movement of trains of different classification and tonnage consistent with dispatching and resistance due to speeds that will come well within the established limits of reliable, efficient and economical Transportation, Motive Power and Maintenance of Way performance, and allow of the minimum first cost, interest, depreciation, taxes and insurance for roadway and equipment.

Therefore, before deciding that electric locomotive performance will justify the high cost for the installation of a rapid, uniform, continuous speed system for the handling of light and heavy tonnage over one track,

care should be exercised that comparison is made with the best steam locomotive practice obtainable, as otherwise the determinations may be misleading and result in costly experiences, particularly through the load factor.

Effort has been made in the preparation of the attached tabulated and descriptive information to compile such data, photogravures, diagrams and profiles as will make the study of the present Mallet articulated type locomotive operation in North and South America self-explanatory, but the following additional information may be of interest.

These locomotives were used in the mountainous districts of Europe for a number of years before 1904, at which time the design was modified to suit the American requirements. They are adapted for general road as well as helper freight service and the same ratio of efficiency will obtain for the lighter as with the heavier designs.

The particular features are—the greater proportion of the total weight that is distributed over a shorter rigid and a longer flexible driver-wheel base; the comparatively low driver-wheel loads; the relatively higher tractive power per unit of weight per wheel; the automatic regulation of the tractive effort between the two sets of engines; the distribution of the tractive power between two groups of driver-wheel bases, running gear, frames and cylinders; the introduction of the compound principle with independent cylinders and large intermediate receiver capacity; the greater reserve capacity in the boiler and through the use of direct pressure steam in the low pressure cylinders; the combination of extreme power in two sets of engines with one boiler and tender under the control of one engineer and fireman; a greater percentage of paying tonnage to be hauled per total weight of locomotive and train and less liability for complete disablement.

BALTIMORE AND OHIO RAILROAD PERFORMANCE.

The first locomotive put into operation in this country was for the Baltimore & Ohio Railroad, its object being to determine upon the practicability of such a class of motive power to efficiently and economically increase the capacity of a busy, mountainous line in event that might become necessary. The design of the experimental locomotive decided upon was of the Mallet articulated duplex compound steam type, and the construction was completed in April, 1904, after which the locomotive was exhibited at the Louisiana Purchase Exposition, and later put into regular helper freight service on the Connellsville Division on January 6, 1905.

The following data are self-explanatory and show the actual results from the performance of this locomotive for the three and one-third year period ending May 5, 1908:

	Freight Service.		
	Road.	Helper.	Total.
Engine crew or Constructive Mileage (on basis of 6 miles per hour)	1,798	139,104	140,902
Locomotive or Actual Mileage	1,798	76,601	78,399
Time available for Transportation Department use	1,027 days or 84.5%.		
Time unavailable for Transportation Department use	189 days or 15.5%.		
Water used per pound of coal consumed	6.23 lbs.		

Cost in Cents Per Mile Run.

FOR	On Basis of	
	Constructive Mileage.	Actual Mileage.
Engine crew hire	$10.16	$18.27
Fuel	9.30	16.71
Repairs	4.96	8.92
Wiping, hostlering and dispatching	.89	1.60
Lubricating oil, grease and waste	.51	.91
Water	.45	.82
Sand, illuminating oils and other supplies	.29	.51
Total Cost	$26.56	$47.74

The actual mileage includes only the road miles made by the locomotive and does not provide for the time that it was crewed and waiting for trains, working around terminals and switching, a considerable proportion of which occurs in helper freight service and for which an allowance is made in the constructive mileage.

The following essential features, which were somewhat radical as compared with the ordinary American railroad practice at the time this locomotive was designed, have given entirely satisfactory results: Articulated frame; elimination of truck wheels; Mellin system of duplex compounding and simpling; flexible joints to the receiver and exhaust pipes; Walschaert motion gear; combination hand and power reversing gear; high pressure piston and low pressure double-ported slide valves; high and low pressure steam balanced piston packing rings; method of securing high pressure cylinders to boiler; single disk balanced main throttle valve and 235 pounds working steam pressure.

No difficulty has been experienced with the tracking and riding qualities going forward or backward, around maximum curvature or on straight track, either when pushing, pulling or breaking trains or running light. The performance has demonstrated that neither leading nor trailing

truck wheels are necessary, which overcomes the objection to the added dead weight, increased number of revolving, swiveling and other parts and greater number of wheels and bearings for wear and lubrication. There is also the objection to truck wheels due to the increased resistance levers and friction when entering and leaving curves as produced through the supporting centers having to be carried farther forward from the swiveling point than would be necessary where truck wheels are not used and which latter arrangement provides a more flexible balancing and curving locomotive. The driver-wheel end play and flange wear has been more favorable than, and on slippery rail there is not the same relative loss of power as with the Consolidation type locomotives, for the reason that in the former there are two separate sets of connected driver-wheels and engines which can act automatically independent of each other in regulating the tractive effort, whereas with the latter all driver-wheels must act in unison.

With oil lubrication to the driver axle bearings, to the present date but one journal has required turning due to heating.

The combination of surge plates in the boiler with the use of the single disk main throttle valve has eliminated priming and provided dry steam at the high-pressure steam chests, and no trouble has been experienced with condensation in the low-pressure cylinders.

There has been no trouble due to trains parting either when pulling or pushing and the following table shows the weights on driver-wheels and the tractive and horse-powers as compared with other steam and electric locomotives performing similar service, at running speeds of 10 miles per hour:

Kind of Locomotive.	Weight on Driver Wheels in Pounds.	Tractive Power in Pounds.	Horse-power.
Mallet Articulated, steam,			
In Simple Gear	334,500	91,300	2,434
In Compound Gear	334,500	71,500	1,906
Two sections, electric	320,000	70,000	1,866
One section, electric	160,000	35,000	933
Consolidation, steam	173,000	42,168	965

The Mallet locomotive has been operated by regular and pooled crews consisting of one engineer and one fireman and the latter have not been taxed to their physical capacity.

Injectors of 4,500 and 5,000 gallons per hour capacity are used on the left and right sides of the locomotive, respectively, either of which will supply the boiler when developing the maximum horse-power.

No defects have developed in the boiler sheets or in the method of attaching the high-pressure cylinders to the same. The fire-box is in

excellent condition and with the exception of a few fire cracks extending from some of the rivet holes at the seams and at the furnace-door holes, but which have given no indication of leakage, is as good as when applied. The number of solid staybolts removed for partial and entire fractures and all other causes is 158, and the 2¼-inch diameter 21-foot length flues have been reset but twice, not including the third resetting, which will be made this month.

The fire-box, staybolt and flue performance of this locomotive operating with 235 pounds indicated steam pressure has been more favorable than for Consolidation simple type locomotives working under the same fuel, water and service conditions with 205 pounds indicated steam pressure.

The flexible joints at each end of the receiver pipe which conveys the high-pressure cylinders exhaust steam to the low-pressure cylinder valve chambers have received no attention with respect to either renewals, repairs or adjustment and there has been no leakage, probably due to the fact that the long lever arm results in but slight movement of the joints.

The Walschaert valve gear, which is the oldest now in use on any locomotive in this country, has more than demonstrated its superiority in every respect over the Stephenson and similar forms of motion gear for modern locomotive construction.

Taken as a whole, the design of the locomotive can be considered as satisfactory, and the only changes found necessary or made in the original construction have been to strengthen a weak cross equalizer and the driver springs; to change the flexible connections between the oil delivery pipes and the low-pressure cylinder steam chests and to rearrange the rocking and drop grates and operating gear.

While the locomotive receives fire cleaning, fuel, sand, water, washing out and minor running repairs at Rockwood, Pa., from which point it is dispatched for helper freight service, the heavier running and the classified repair work must be done at the divisional enginehouse at Connellsville, Pa., to which station it is diverted at periodic intervals.

As compared with Consolidation simple type locomotives the fuel consumption per ton mile is considerably less on the level, somewhat less on the combined level and mountainous and slightly less on the mountainous lines.

This locomotive is doing the work of two standard Consolidation simple locomotives and the results from its service has more than met the expectation of the builders and owners and has established the practicability and the advisability for the use of this class of power for the purpose as intended.

ERIE RAILROAD PERFORMANCE.

The Erie Railroad put into service during September, 1907, three Mallet articulated duplex compound steam types of helper freight locomo-

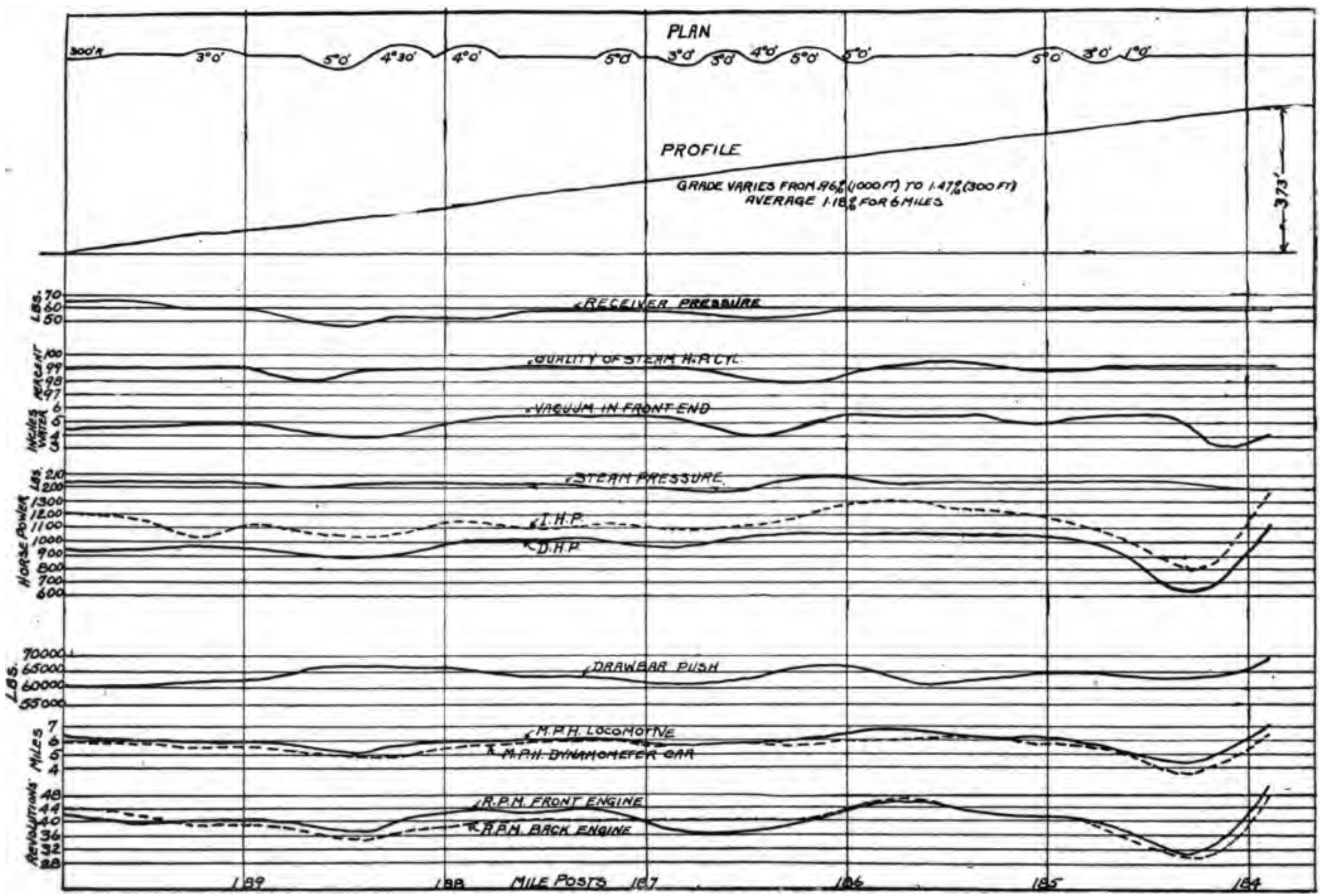

PLAN
300'R
3°0'
5°0'
4°30'
4°0'
5°0'
3°0'
3°0'
4°0'
5°0'
5°0'
5°0'
3°0'
1°0'
PROFILE
GRADE VARIES FROM .96% (1000 FT) TO 1.47% (300 FT)
AVERAGE 1.18% FOR 6 MILES
373'
RECEIVER PRESSURE
QUALITY OF STEAM H.P. CYL.
VACUUM IN FRONT END
STEAM PRESSURE
I.H.P.
D.H.P.
DRAWBAR PUSH
M.P.H. LOCOMOTIVE
M.P.H. DYNAMOMETER CAR
R.P.M. FRONT ENGINE
R.P.M. BACK ENGINE
LBS.
PERCENT
INCHES WATER
HORSE POWER
MILES
REVOLUTIONS
189
188
MILE POSTS
187
186
185
184

Fig. 1.

the results of a sixty-trip test shows 11.04 pounds of coal consumed per 100-ton miles west-bound, and 9.27 pounds of coal consumed per 100-ton miles east-bound. The performance of the Consolidation locomotives over the same district for the fiscal year ending June 30, 1907, averaged 19.25 pounds of coal per 100-ton miles, showing a saving of approximately 47 per cent in fuel consumption.

On the district between Clancy, Mont., and Moodville, Mont., the annual performance of Consolidation locomotives averaged 33.1 pounds of coal per 100-ton miles. From a series of tests made with the Mallet locomotives during March of this year, with an increase of 33⅓ per cent in the train tonnage, the coal consumption was somewhat less than 25 pounds per 100-ton miles.

The conclusions with respect to the operation and maintenance of the Mallet road and helper freight locomotives as put into service on the Great Northern Railway Line is as follows:

OPERATION. Very little trouble has been experienced in the handling of the heavier trains on the mountainous districts and less difficulty has been experienced on account of break-in-two's as compared with the simple Consolidation type locomotives, which is accounted for by the automatic independent action of the two sets of connected driver-wheels and engines. It has also been demonstrated that the firing of these locomotives with the quality of fuel available is within the capacity of one fireman, although the use of some type of locomotive stoker is being considered on account of the heat from the furnace door opening.

From the performance to the present date it is thought that a considerably lower ratio of adhesion is permissible with the Mallet type locomotives as compared with other classes.

DESIGN. The question of flange wear was carefully considered due to the fact that the locomotives would be required to operate in both directions without turning. It was decided to provide leading and trailing wheels in combination with radial trucks and the results have been very satisfactory.

MAINTENANCE. The cost for repairs per mile run will necessarily average higher than for the simple Consolidation locomotives, but on the basis of 100-ton miles it is materially reduced.

While no trouble has been experienced in keeping the flexible low-pressure steam and exhaust pipe joints tight they have required considerable attention and consideration is now being given to the use of a metallic packing.

On the first locomotives built the high-pressure cylinder saddles were secured to the boiler shell by means of studs, which caused considerable trouble due to their working loose and leaking. This difficulty has been overcome by the use of cast-steel cylinder saddles, which are riveted to the boiler shell.

During the winter months some trouble was experienced through having to keep the cylinder cocks open to relieve the condensation due to the low pressure steam coming in contact with the low pressure cylinder large wall area. It is the opinion that the use of some form of reheater or superheater would overcome this difficulty and bring about a considerable improvement in the efficiency.

On account of the trouble experienced in supplying sand to the rail ahead of the first driver wheels to the low-pressure or articulated engine, it was found necessary to locate an independent sand-box between the cylinders of the low-pressure engine, and which has overcome the difficulty due to the original sand-box location on top of the boiler.

The foregoing information is self-explanatory as to the results that have been obtained from the use of these locomotives, and justifies the general conclusions as set forth in this report.

NORTHERN PACIFIC RAILWAY PERFORMANCE.

The Northern Pacific Railway now has in helper freight service 16 Mallet locomotives of similar type to those in use for the same class of service on the Great Northern Railway. Two of these locomotives are now in use on the Cascade Mountain Lines, and from which operation it is expected to secure some valuable comparative performance data. While some weak points have developed in the operation and maintenance, more especially in connection with the flues, the locomotives in general are rendering good service and haul an increase of about 300 tons in train up a 2.2 per cent grade as compared with the other heaviest types of mountain-line locomotives in similar service on that railroad.

CHICAGO, BURLINGTON & QUINCY RAILROAD PERFORMANCE.

The Chicago, Burlington & Quincy Railroad has had one of the Great Northern Line helper freight Mallet locomotives in their service for some time past and has recently put into use two additional locomotives of this type. To the present date your committee has been unable to secure any detailed information of the performance of these locomotives except such as pertains to the one Great Northern Line type, and which is included in the tabulation, photogravure, diagram and profile sheet and comparative performance data compilation.

AMERICAN RAILROAD OF PORTO RICO PERFORMANCE.

Three of the four Mallet locomotives in use on this railroad operate between Mayaguez and Lajas to transport the sugar-cane traffic.

Two locomotives, each in service about sixteen hours, handle a total of ninety loaded cars, each of 15-tons capacity, every working day, while the third locomotive is retained in reserve.

From Mayaguez to Filial Amor the Mallet locomotives are assisted

DATA PERTAINING TO MALLET ARTICULATED COMPOUND LOCOMOTIVES NOW IN SERVICE OR UNDER CONSTRUCTION IN NORTH & SOUTH AMERICA.

ITEM NUMBER	REFERENCE TO PLATES.		
	PHOTOGRAVURE	DIAGRAM	PROFILE
1	SHEET 1	SHEET 1	SHEET 1
2	SHEET 2	SHEET 2	SHEET 2
3	SHEET 3	SHEET 3	SHEETS 3 TO 8
4	SHEET 4	SHEET 4	SHEETS 9 & 10
5	SHEET 5	SHEET 4	SHEETS 11 & 12
6	SHEET 5	SHEET 4	SHEET 13
7	SHEET 6	SHEET 5	NONE
8	SHEET 7	SHEET 6	SHEET 14
9	NONE	SHEET 6	NONE

motive engine is uneconomical, but at the same time, where you are dependent upon an outside source of power, and where the load factor is a fluctuating item, on account of double the rated capacity of the motors being required to start the train and only one-quarter the rated capacity of the motors being required after starting, is an expensive system, and while it compares unfavorably at the present time, unless we decrease the cost of operation by decreasing fuel consumption, and increasing the capacity of locomotives, the electric locomotive may prove a competitor later on, particularly where water power is available.

One objection to electrification for heavy tonnage service is the high first cost, due to power plants, contact and transmission lines, and other auxiliary equipment, as well as the locomotives, but that is something which will be gradually reduced and the fixed charges decreased and greater economy brought about in that way.

In the matter of steam railroad electrification, the people who are at present the most enthusiastic are the ones who design and install the electric systems. Up to the present time I have not heard anything very favorable from the people who are required to maintain and operate the electrical equipments, and as they are the ones who should be the real judges of the efficiency of the installations, we understand from them that they have been relatively very expensive.

As I have said, in order to keep the steam locomotive economical and efficient, the improvement of the boiler as well as of the steam distribution, should receive serious consideration, particularly where heavy trains are to be handled, and in view of the increased cost of conducting transportation accounts, such as wages of engine and train crews and cost of fuel and supplies, it is very essential that the tractive power of the locomotive be increased as much as is permissible.

THE PRESIDENT: This report is now before the Association for discussion. Mr. Clark, have you anything to say in this connection?

MR. CLARK: Mr. President, about all the information I have upon this subject is contained in the report. I was one of the members of the committee and felt in duty bound to give the

committee all the information I had, which was not very much. We have three Mallet compounds in service at the present time, but personally I do not know very much about them. They have only been in service for two or three months; I hear very little of them, but assume they are doing good work.

THE PRESIDENT: Is there any other gentleman present who has had experience with the Mallet type of engine? Mr. Rumney, can we hear from you?

MR. RUMNEY: I believe that all the information we possess has been incorporated in the report. We tried to cover the matter as thoroughly as possible, but it was unfortunate that we were not able to obtain, at the time of the test, a dynamometer car of sufficient capacity to get the full tractive power of the engine, consequently the report is not as valuable as we would like it to be.

The engines have given very satisfactory service, but you will see, from the report, that the maintenance cost is high. This is, perhaps, due to the fact that we were not as well equipped, by reason of experience, to handle the repairs as promptly as all other and more prevalent types of locomotives.

THE PRESIDENT: Mr. Vauclain, we would like to hear from you on this subject.

MR. VAUCLAIN: Mr. President, I think this is one of the best reports that has been brought before the convention. There are one or two things that I do not quite agree with, however. Mr. Muhlfeld claims one advantage of a Mallet engine, is the opportunity to get on so much larger boiler. I think those who have the Mallet design find that there is considerable difficulty to get the large boiler and keep the weight down to the limit per driving axle.

You will notice on the smaller type locomotives which we built for the Great Northern Road, if you are familiar with their power, you would find that the boiler on this locomotive is the same size exactly as the boiler on their Pacific type passenger engine, so that with a locomotive with fifty per cent more weight on drivers we have practically the same boiler, but the high efficiency which we are able to obtain from this engine makes

this boiler sufficiently large for the maximum capacity for the work to be performed. Of course, with the use of trucks front and back in the Mallet locomotive we are enabled to get additional boiler capacity, and therefore I am in favor of a leading and trailing truck for the larger types of Mallet engine on that account, because with the same weight on driving wheels, by the use of the trucks, we are able to put all excess weight into the boiler.

Mr. Muhlfeld also called attention to the opportunity for intermediate superheat and that is a matter that is not only being considered tentatively, but is absolutely being designed and will be put into service very shortly.

I wish to call attention to what I think is a very bad feature in this report, and that is the record of the dry steam consumption of the Mallet engine on the Erie Railroad. I do not like to see it, because I do not think it is true. I do not believe that any Mallet type of compound engine will use as high as thirty-seven pounds of dry steam per indicated horse-power, or 42.4 pounds, as quoted here, of dry steam per dynamometer horse-power. It will not do that, unless there is a straight line connection between the high-pressure steam pipe and the smoke stack, and my idea is that the engineer may have been afraid of his water in these trials or the gauge cock may have been entirely too high for the grade and that considerable solid water flowed over, and those making the tests failed to take account of the solid water, while they may have taken account of some of the moisture in the steam, because I do not believe that steam with only two per cent of moisture in it would give any such results in a Mallet compound as forty pounds of dry steam per dynamometer horse-power.

My opinion is it was about twenty pounds of dry steam per horse-power and having reference to the reports of the Great Northern locomotives, the tests of which were made under more excessive climatic conditions, these reports would show that it must have been about a twenty-pound water rate, at least not over a twenty-pound water rate.

I feel that the subject of Mallet compounds is one that should be freely discussed at this meeting because before we have another

meeting I am inclined to believe that a great many railroads will be using Mallet compound locomotives. It has been definitely demonstrated that these engines are not so well adapted to the mountain pusher service as they are to low-grade freight service, and the highest economies they are showing, while they are highly economical in mountain service, are those in low-grade service, and they are being put to work on grades as low as 6-10 of one per cent and are being considered by a road which has only a grade of 2-10 of one per cent.

We are bound to adopt the very largest type of locomotives in our freight service; our cars are being increased in capacity, and lately the question has been brought up of still further increasing the capacity of our freight cars for certain classes of traffic, and when we do that we must have a locomotive that is easy to maintain, economical in service, which can be handled by two men, an engineer and fireman, with such mechanical appliances as we may see fit to adopt such as a coal pusher for the tender to place the coal at the fireman's feet, so that he will not have to walk after it, and in this way the type of locomotive for freight service is going to gradually change from the single unit to the Mallet or compound unit.

MR. C. J. MELLIN (American Locomotive Co.): In reference to the test made with the Erie engines, it should be remarked that this test was made neither by the railroad nor the builder of the engines, but due to the general interest these engines had created, a few students of the graduating class at Cornell University obtained the permission of the railway to make a test on those engines on which to base their thesis for examination.

The young men came to Susquehanna with the various testing apparatus and had them applied to one of the engines just as it was after six months' service, during which time I learned that no repairs had been needed except replacing a couple of rod brasses and that neither a cylinder head nor valve-chest cover, etc., had been removed from the engine since it arrived on the road, but that the engines had done, and still were doing, the work of the three engines it replaced very satisfactorily.

The piston-rod packings blew a great deal and it is probable that after so long service that there was some leakage through

pistons and valves that to some extent may account for the apparent heavy water consumption.

The engines are held in the highest esteem both by officials and men, and are considered as very economical in fuel consumption as compared with the former engines in same service, and it was generally regretted that the service condition did not admit of putting the engine in a first-class order before the test.

In regard to the front and rear truck, that Mr. Vauclain advocates, I am not entirely of that opinion, for I find that we get a better engine, going ahead as well as going back, without trucks, because the trucks elongate the leverages and the front truck is certainly a great objection when an engine of this kind is backing, and the rear truck would not be necessary. We are building now an engine with only a front truck, and we are building it under protest, for if we go forward the truck is doing no harm and it does not do any particular good; but in going back it is a serious matter to have an engine with a front truck. I would not advise backing very fast with an engine that has to overcome the resistance of the front truck.

MR. VAUCLAIN: In regard to this front truck matter, if you hitch two six-wheel switchers together and start them over a railroad, you have to regulate their speed or you can not get to their destination. The Mallet engine has some of this rocking motion, and by the introduction of a truck at either end we overcome that action, the same as we overcome it when we make a Mogul locomotive do freight service instead of using a six-wheel coupled engine. It is more noticeable the shorter the wheel base. Where we use a six-wheel engine for switching service, we make the wheel base as long as possible on that account.

But there is in addition to that, and the advantage of adding additional locomotive boiler capacity to a locomotive of this kind, a third reason, and that is the increased influence of the friction between the drawbar of the locomotive and the drawbar of the car, due to the thrust of the locomotive when operating at maximum power. If we have a locomotive having a tractive power of 80,000 pounds, we have a vertical resistance between the couplers of 20,000 pounds. This vertical resistance, if not supported through the connection of the driving spring to the front axle, as

it would be in a Mallet engine without a truck, gives more serious consequences than when supported by the intermediate mechanism of the front truck.

The President: Is Professor Hibbard in the room, or any one associated with Mr. Hibbard in making the test that Mr. Mellin has referred to? I believe they were made under his superintendence.

Mr. Sanderson, I understand that you have been looking into the matter of compounds, the Mallet type, etc. Do you wish to say anything on the subject?

Mr. Sanderson: No, I have nothing to say.

Mr. Muhlfeld: I would suggest, Mr. President, and will make a motion to that effect, that the committee's report be accepted as describing the progress that has been made to the present time with the Mallet type of locomotive, the report covering about one hundred of that type in use on some of the principal railroads. I think it is about all the data we have available at the present time. (The motion is carried.)

The President: The next subject before us, gentlemen, is the result of tests with the briquetted coal made on a locomotive testing plant of the Pennsylvania R. R. at Altoona. Mr. A. W. Gibbs.

Mr. Gibbs: Mr. President, I submitted to the Association an abstract of the results of our tests of briquettes, and Mr. Nelson, who did the work, is here. I will ask him to read it.

RESULT OF TESTS OBTAINED WITH BRIQUETTED COAL MADE ON THE LOCOMOTIVE TESTING PLANT OF THE PENNA. R. R. CO., AT ALTOONA, PA.

To the Members:

These tests were carried out under the direction of Dr. J. A. Holmes, Expert in Charge, Technologic Branch, United States Geological Survey.

It was intended to ascertain if low volatile coals of a semi-smokeless nature but friable and, therefore, not fairly satisfactory in locomotive use, could, when briquetted, be used to reduce the amount of smoke and prevent the loss sustained from the discharge of cinders, which is large in coals of this character.

The coal selected had the following proximate analysis:

Fixed carbon	73.21 per cent
Volatile combustible	17.75 per cent
Moisture	2.43 per cent
Ash	6.61 per cent
	100.00 per cent
Sulphur	1.34 per cent
Calorific value, B. T. U.	14918

A series of tests was run with the raw coal and another series with the same coal briquetted in two forms, square and round, and experiments were made with the percentage of binder from 5 per cent to 8 per cent.

All tests were run on the Locomotive Testing Plant, a simple cylinder Atlantic type locomotive being used, having a total heating surface including fire side of tubes of 2,320 square feet and a grate area of 55.5 square feet. The results give the full performance of the boiler, together with the draw-bar pull.

The series with the raw coal were run in such a way as to show the full performance of the boiler from low rates of evaporation to the highest possible rate of evaporation. The lowest rate of evaporation was about 18,000 pounds of water per hour, equal to 8 pounds per square foot of heating surface; this being increased throughout the test until, with the briquetted fuel, an evaporation of 44,500 pounds of water from and at 212° F. was obtained. This is equivalent to 19 pounds of water per hour per square foot of heating surface.

The briquettes were fired with ordinary shovel and handled in the manner usually employed for coal, no necessity being found for breaking the briquettes.

The following table taken from a plot of actual results shows comparatively the evaporation of the natural and briquetted coal.

When the rate of evaporation per square foot of heating surface is, pounds.	The equivalent evaporation per pound of fuel is, for	
	Natural Lloydell coal, pounds.	Briquetted coal, pounds.
8	9.5	10.7
10	8.8	10.2
12	8.0	9.7
14	7.3	9.2
16	6.6	8.7

The quantity of cinders collected in the smoke box showed no material difference as between the raw coal and the briquetted coal. The quantity collected per hour when burning 100 pounds of fuel per square foot of grate was about 400 pounds, reaching a maximum of about 750 pounds

per hour with the coal being burned at the rate of 120 pounds per square foot of grate.

Fire-box and smoke-box temperatures were practically the same at the same rates of evaporation, whether the coal was used in its raw state or briquetted.

The apparent reason for the increased evaporation per pound of fuel with the briquetted coal is that, although, as already stated, the loss due to cinders in the smoke box is not different as judged by the quantity collected, the calorific value of the cinders from the briquetted coal was lower than with raw coal, and, further, on account of the uniform size of the briquetted fuel the distribution of air through the fire permitted more complete combustion and liberation of heat than with the raw coal.

The fuel consumed per draw-bar horse-power with the locomotive running at a speed of 37.78 miles per hour and a cut-off of 25 per cent was as follows:

Raw coal ....4.48 pounds
Round briquettes ....3.65 pounds

This is equivalent to stating that the amount of briquetted coal was 81 per cent of the amount of raw coal required per draw-bar horse-power at this speed and cut off.

Smoke observations were made by Ringelmann's method and by photographs. By this former method no smoke is indicated by 0 and very black smoke by 5. There being a total of six gradations from 0 to 5 inclusive.

The following table indicates for a portion of the speeds and cut-offs the comparative smoke readings, these being an average of a large number of observations made at regular intervals.

Speed, miles per hour.	Cut off.	Average smoke.	Kind of fuel.
	Per cent.		
28.34	20	1.2	Raw coal.
28.34	20	0.8	Round briquettes.
37.78	25	1.8	Raw coal.
37.78	25	0.7	Round briquettes.
37.78	30	2.1	Raw coal.
37.78	30	1.8	Round briquettes.

It is evident from the above that the briquetting of this coal materially reduced the amount of smoke, but it could not be determined whether difference in percentages of binder used made any difference in the smoke produced.

At the end of one test at about 37 miles per hour and a cut-off of 32 per cent, the locomotive was shut off and the blower put on and at the end of two minutes the smoke had entirely cleared from the stack.

Various supplemental tests indicated that with care the locomotive

could be brought into a terminal where smoke was objectionable by the proper use of blower and judgment on the part of the engineman in regard to the amount of fuel in the shape of briquettes fed to the fire.

There was no difficulty in starting the fire with briquettes, the same method being used as with the raw coal.

To determine the effect of weathering, a number of round and square briquettes were placed on the roof in January and February and examined in May or about four months after, and these showed no change whatever in their condition.

For these tests, the briquettes which had been made at the station of the Geological Survey were shipped to Altoona carefully stacked in open gondola cars and were carefully unloaded and restacked. Very few were broken and the amount of fine coal abraded from the surface was practically negligible.

This method of handling was all carefully done, but if the briquettes had been shipped for regular locomotive service it is not thought that the breaking and abrasion of handling briquettes would be a serious matter for regular service.

A. W. GIBBS.

MR. NELSON: Since we have had the locomotive-testing plant we have stopped talking about whether a locomotive is a good steamer or a bad steamer, and we now measure the capacity of the boiler by saying that it will evaporate so many pounds of water per square foot of heating surface. With gas coals we have obtained as a maximum nearly eighteen pounds, and probably in road service we get about twelve pounds of water per square foot of heating surface. I noticed just now in connection with the discussion of the report on Mallet compounds, that that boiler on the Erie Railroad evaporated an equivalent of about nine pounds of water, so that this figure mentioned in this report of nineteen pounds is very remarkable.

I think the United States Geological Survey in their test of fuels have found a very large economy when the fuel was of uniform size, and this seems to mean that with fuel of uniform size the air is permitted to get in contact with the burning fuel and more economy results.

We have exposed, recently, the briquettes to the weather. They seem to deteriorate in spots. You will find here and there a bunch of briquettes that are going to pieces, while those which are close to them are still hard and in good condition. I am not prepared to explain why this should be.

The President: This report is before you now for discussion. I just want to say that yesterday a gentleman spoke to me who is connected with a briquetting plant on Staten Island, and asked for the privilege of explaining their methods. If he is present I would like to have him take the floor, if it will be agreeable to the gentlemen present to have him do so.

Mr. Angus Sinclair: Mr. President, I move that the gentleman be permitted the privilege of the floor.

Mr. Egbert: Mr. President and Gentlemen: I wish to thank you for the opportunity of addressing your members, but I think it would be in poor taste for me to stand up here and talk up our briquettes. I came here with the idea, not of talking up the product, but merely of listening to the discussions of your Association. If there is any one here who wishes to ask any questions on the subject I shall be perfectly willing to answer them.

Mr. W. H. V. Rosing (Mo. Pac. Ry.): Mr. President, from the experience we have had with coal in briquette form, I find the success of this coal, as compared with coal of like character in other forms, is due largely to the pressure with which the briquette is made. We made numerous experiments with briquettes manufactured by the Geological Survey, at St. Louis, the first ones being rectangular in form, similar to a building brick, and necessitating breaking before firing. The breaking and handling of the briquettes accumulated about twelve per cent of slack. These briquettes were made in a machine of foreign manufacture and were not sufficiently hard. Later machines were, however, introduced and briquettes made in lentil form, weighing about one-half pound each. These briquettes gave fully as good results in actual locomotive practice, as the report of the testing plant indicates. We found that briquettes made from any class or grade of fuel, either bituminous or semianthracite, gave proportionately better results than of the same grade of fuel in any other form. The question of briquetting coal is one of considerable importance, especially where mines produce a large percentage of slack. The Arkansas mines, which furnish the Mo. Pac. Ry. with considerable coal, average from fifty to

fifty-five per cent slack and they can not always find a market for this material.

Comparing the briquette with lump coal in the fire box, we found the gases emitted from the lump coal would come out in parallel planes with the veins of the lump coal and would not properly mix with the air passing around the lumps, while with the briquette, which is a homogeneous mass, the gases seem to come out from all sides and mix with the air as it passes by and through the fire. The briquettes were consumed from the outside and would not burst or break open in giving out the gases, thus retaining a resemblance to the original shape at all times, only diminishing in size, even with moderate shaking of the grates, and would therefore maintain uniform air spaces.

The smoke emitted from the stack when the briquette fuel was used was reduced about fifty per cent over lump coal of the same grade.

Mr. Nelson spoke about some of the briquettes deteriorating with age. In my opinion this is due directly to the low pressure under which the briquettes were manufactured. We had several tons of briquette coal which had been piled in the open air for a period of about three years which showed no perceptible change in condition. In making our tests with briquette coal, we unloaded it from a car into the chutes and then dumped it into the tender in the usual way. We found practically no breaking up of the briquettes made under high pressure. It was also found that less binder was required with the high pressure. An average of five per cent of coal tar binder was used in the briquettes above referred to.

The management of the Mo. Pac. Ry. deems it advisable to store considerable quantities of coal during certain periods of the year and we store in the neighborhood of 500,000 tons annually. We have always had more or less trouble with spontaneous combustion in these coal piles and last year we lost about eight per cent by destruction by fire from this cause, the reason being that iron pyrites in the fissures of the coal is oxidized to an extent which causes heating to the point of ignition. In briquette coal this chemical is entirely broken up and in such physical form that coal can be stored for practically an indefinite period without the coal being destroyed by spontaneous combustion.

The smokelessness of the briquette coal is a very desirable quality and is now receiving considerable attention from the Naval Department, and I think about 1,200 tons was tested on Admiral Evans' Flag Ship before his trip around the Horn. It seems the reduction of smoke from the immense funnels of a battleship is of more importance than economy of fuel consumption, on account of the unobstructed view while in action.

Mr. DeVoy: Mr. President, I would like to inquire, before this discussion is closed, whether there has been any attempt made to briquette Montana coal, and if so, what constitutes the method and as to the cost. It has become a very serious problem with us how to handle Montana coal on account of its lightness and disposition to throw off sparks. It seems all right, and if there is anybody that has that information, as to whether it has ever been mixed with other coal, or handled in any way, we would be glad to know. If anyone present can give us that information we should be thankful.

Mr. Forsyth: A number of years ago Mr. Rhodes had charge of an investigation of that kind, and he had some of that Montana lignite shipped to a briquette plant in the East. The results obtained were given in a report to the motive power department of the Burlington Road, and the figures can be obtained there, I have no doubt. As I remember it, the cost of briquetting was rather high and almost prohibitive. I think that is the case generally. The gentleman from Staten Island might perhaps advise us as to that.

Mr. Egbert: Mr. President, I have not heard of any of the Montana lignite coals being briquetted, but we have taken samples of the North Dakota coal and briquetted them very satisfactorily. The cost of manufacture depends upon the coal. Ordinary lignite will run about $1.00 per ton for the cost of briquetting.

Mr. DeVoy: Do you know anything about the semi-lignite coals?

Mr. Egbert: Well, those coals can all be prepared, there is no question about that, but it all depends upon the quality of the coal and the amount of binder used.

Mr. Manchester: Have you any information as to whether it reduces the firing qualities?

Mr. Egbert: Yes. As to this disintegration in storage, that depends on the binder used, whether it is water and weather proof. The ordinary pitch makes a good binder. Other binders will have the effect of the disintegration which Mr. Nelson speaks of.

Mr. Manchester: What I had specially in mind was that property or peculiarity of lignite coal to spark and fly off and stay alive. Does it have the effect of destroying that property?

Mr. Egbert: It does, yes, sir. The briquette will lie in the fire compactly, and will burn evenly from the outside and there will be no discharge of sparks.

Mr. DeVoy: I just want to say, as a matter of information, that if there is any man who can, and with success, burn the coal up there, that there is a very fertile field for his efforts. The American Locomotive Co. has had Mr. John Player out in that country for the past six months. He is now at Sheridan, Wyoming, and, I believe, experimented with it. I have been on the Northern Pacific and have seen them try to burn it. You can burn it all right, but if you attempt to get any sort of results from it, you will have to clean your front ends at least every hour, and, if you adopt any new smoke-box appliances, even in the form of the old wood-burning stack or the double system of netting, you will have trouble. If briquetting can be done economically and the coal handled successfully, there will be a fortune in it. I believe we should at least attempt to briquette it or mix it with something else, if it can be done, but there is nobody up that way doing it that I know of.

Mr. Rosing: In observing the cinders from briquette coal we find that less cinders are thrown than from screened lump coal, and I would say, in a general way, that the throwing of cinders is reduced in about the same extent as the reduction of smoke. I have no figures on the cost of the briquetting coal, but in figuring it up with officials of the Geological Survey, it was found that the binder was one of the great items of expense. The least we could purchase a binder for was $9.00 a ton, and

five per cent binder will add 45 cents per ton to the briquette fuel. This is not all lost, as the coal tar gives up some heat. In making a comparison of the efficiency of the lump coal with briquettes of the same material, on an evaporative basis, and rating our lump coal on the tender at $1.70, we found that we could afford to pay $2.23 for the same coal in briquetted form.

Mr. L. R. Pomeroy (Safety Car Heat. and Ltg. Co.): Mr. President, before the subject is closed, I would like to call attention to one or two facts. You will notice in the second paragraph, page 2, that all tests were based upon 2,320 square feet of heating surface, which is the heating surface at the fire side of the tubes, and inasmuch as some comparison of evaporation has been made in the Mallet compound report, which is based on heating surface measured at the outside of the tubes, I would like to request, before the paper goes into the Proceedings, that the committee also give the equivalent evaporation in the form in which most of our statistics are presented to the Association, namely, the water side of tube surface. For example, the third paragraph says, "the lowest rate of evaporation was about 18,000 pounds of water per hour, equal to eight pounds per square foot of heating surface." On the basis of the heating surface as it is used in the Proceedings of the Association, this figure would become seven pounds, in other words, from ten to twelve per cent less. I am aware that the method of using the fire side of the tube was used at the St. Louis tests, but inasmuch as all the figures of record in the Association are based on the water side of the tubes, and the Association is not on record as to making any change, that when tests are presented based on the fire side of tubes the equivalent figures for the accustomed tube-heating service should also be given.

The President: Mr. Nelson, have you any explanation in that respect? This matter can be easily turned over all right.

Mr. Nelson: Yes, that addition could be very easily made. The reason we have taken the fire side of the tubes is because the Advisory Committee in connection with the St. Louis test, three of whom were appointed from this Association, decided that that was the proper basis for measuring the heating surface, and we

have followed it ever since, although in most of our reports we have taken both.

THE PRESIDENT: Is there anything further on this subject? Do you want to say anything further in closing, Mr. Nelson?

MR. NELSON: I have nothing to say.

MR. GIBBS: There is one improvement in the briquettes which I think should receive attention; that is, the character of the cinders discharged from the chimney is an annoying one. When you examine these cinders, they appear to be in the form of little saucers of coke. For some time we were at a loss to explain this peculiar form, but apparently it is due to the fact that the briquette when thrown into the hot fire box becomes a gas generator which burns into coke on the surface, and the gas coming out dislodges that coke in the form of a little thin layer which is so light that it goes off through the chimney. Measurements made at our locomotive testing plant showed that a surprisingly large percentage of the weight of the briquettes fired came out of the chimney in the form mentioned. It occurred to us that if the briquettes could be perforated in somewhat the same way that crackers are perforated to allow the escape of steam, the gas could be burned without dislodging the surface coke, so that the whole briquette would burn in place. I have been hoping to see some experiments made, with the view of overcoming the dislodging of these little cinders; but as it stands now, I believe that locomotives burning briquettes would be considered objectionable if worked very hard in crowded communities.

THE PRESIDENT: Mr. Egbert, can you say anything on that point?

MR. EGBERT: I didn't quite catch that, Mr. President.

THE PRESIDENT: Mr. Gibbs stated that they found that there were little scales thrown off the briquettes in the shape of saucers, driven off by the action of the gas, and his question is whether some means could be found to avoid that liberation by perforation or otherwise?

MR. EGBERT: That can only be avoided in the density of the

briquettes, the pressure, as the gentleman remarked a few moments ago. The density of the briquettes and the pressure that is put on them reduce the amount of binder that is put in, and the more the pressure, the denser the briquettes, and the less binder is necessary to be used in making them. In that way, that can be overcome.

THE PRESIDENT: If there is nothing further on this subject, a motion to close will be in order.

MR. SELEY: Mr. President, I move that the discussion be closed. (Carried.)

MR. VAUGHAN: Mr. President, I move that the introduction of the topical discussions to be opened by Mr. D. J. Redding and Mr. R. D. Smith be presented to the Secretary in written form, and included in the Proceedings, and that those subjects be dropped.

The motion was seconded by Mr. Seley and carried.

TOPICAL DISCUSSION—USE OF NONCOMBUSTIBLE ENGINE HOUSE JACKS.

MR. R. D. SMITH (N. Y. C. Lines): Just for the purpose of starting a discussion on the subject, I will give a short history of my experience with smoke jacks.

Those made of sheet iron corroded badly and were generally unsatisfactory, as they did not last much over three years, and some lines used them made of sheet iron inside and vitrified sewer pipe outside the house. The sewer pipe proved to be more satisfactory than the sheet iron, because of its longer life, but cracks developed, due to changes in temperature, and made it necessary to use iron bands, which gave trouble on account of corrosion.

These different types of jacks gave way to heavy cast iron, but the makers soon learned to make them much lighter, and finally they were made of cast iron not over 3-16 inches thick, lasted longer and were more generally satisfactory than sheet iron.

Wooden jacks weighing about four hundred pounds came into favor, because of their being lighter weight and cheaper.

They were first made square in section with a cap over the top, but owing to draft currents, were changed to round sections made of staves nailed together and banded. The cap on top served to create currents which started the jack burning from the top downward, and this led to leaving the top, or ventilator, off entirely.

A few aluminum jacks have been built, but these are expensive and we have not been able to obtain any information about them. Combination jacks made of cement, wood and aluminum have been used, but experience indicates that wooden jacks are superior.

There are numerous types of non-inflammable jacks now on the market, being made principally of asbestos fiber, called asbestos wood, asbestos board, asbestos lumber, etc. These are made square in section for the sake of economy and have the advantage of being light, but their cost is considerable more than ordinary wooden jacks. A number of such jacks have been designed for use on the B. & A. R. R., the framework of which is pine, and the asbestos wood is fastened to it with screws which are countersunk and covered with asbestos paste.

Recently, a new type of noncombustible smoke jack has been put on the market. It is made of non-inflammable substance which is applied to a galvanized iron wire screen, and the claim is made that it is not affected by acids or heat any more than those of asbestos boards. We have no figures to show the comparative cost, but the experiment will be watched with interest.

On motion, adjourned to Wednesday, at 9:30 A.M.

WEDNESDAY'S SESSION.

President McIntosh called the meeting to order at 9:40 o'clock and said:

Gentlemen, you will please come to order. The Secretary will read a communication from Mr. Charles V. Dudley, President of the American Society for Testing Materials.

THE SECRETARY: The letter reads as follows:

June 23, 1908.

Mr. Wm. McIntosh, President Master Mechanics' Association, Atlantic City, N. J.:

DEAR SIR,— I beg to acknowledge receipt of yours of June 22d, transmitting resolution of the Association inviting the American Society for Testing Materials to visit the exhibits on the Pier on to-day and to-morrow.

On behalf of the American Society for Testing Materials I beg to say that this courtesy is very greatly appreciated and that it is the sincere hope of the management of that Society that as many as possible of the Master Mechanics' Association will attend the meetings of the Society from Tuesday to Saturday inclusive, of this week. These meetings will be held in the Hotel Traymore, except as specified on the program herewith.

Yours very truly,

CHAS. B. DUDLEY, *President,*
American Society for Testing Materials.

THE PRESIDENT: The first subject on the program for this morning is Balanced Compounds. I have just heard from Mr. Vauclain, saying he missed the first train and will be in a little late, and he asks us to postpone this subject until he can get here. As Mr. Vauclain is one of the best-posted men on the subject of the Compound Locomotive, I think we had better accord him this favor.

The next subject which we will discuss is the report of the Committee on Size and Capacity of Safety Valves, of which Mr. F. M. Gilbert, of the New York Central, is chairman.

Mr. Gilbert presented the following report:

REPORT OF COMMITTEE ON SIZE AND CAPACITY OF SAFETY VALVES FOR USE ON LOCOMOTIVE BOILERS.

To the Members:

Your committee appointed to collect data on the size and capacity of safety valves for use on locomotive boilers, and to suggest a method for carrying out tests to determine the data in connection therewith, begs leave to submit the following:

No uniform practice seems to have prevailed in the past in proportioning safety valves to the work they are to perform. The locomotive builders follow specifications of the railroad companies, and it seems to have been the practice of the railroad companies to base their specifications on what has been done before on similar locomotives. The various railroad companies have fallen into the practice of specifying so many 2½-inch, 3-inch, 3½-inch or 4-inch valves, which, when reduced to exact language, does not mean anything definite. Obviously, two 3-inch valves having a sustained lift of ⅛-inch have a greater capacity for the discharge of steam than eight 3-inch valves having a sustained lift of 1-32 inch each. The committee does not wish to convey the idea that the two 3-inch valves having a sustained lift of ⅛ inch are better for the boiler than eight 3-inch valves having each a sustained lift of 1-32 inch. We simply wish to point out the errors that may arise from the practice of specifying so many valves regardless of the sustained lift.

The committee regrets very much that during the past year it was not able to conduct tests and obtain experimental data, which would no doubt prove of value in the solution of this problem. However, we deem it within our province to outline briefly along what lines any future investigations should be conducted.

Perhaps the most important part of any investigation should be the determination of the proper amount of evaporation which the safety valves shall be called upon to relieve. We already have information as to the maximum evaporation of locomotives from the tests at St. Louis in 1904, but the committee feels that the safety valves would never be called upon to relieve this amount from the fact that the combustion in the firebox is stimulated by the exhaust, and that this exhaust is caused from the use of the steam in the cylinders. So that, at a time of greatest evaporation, the steam is being used approximately as fast as it is generated. Hence, it remains for the investigators to determine what shall be deemed the proper amount of relief in safety valves. Then, too, the lift of valves of various sizes at the different pressures must necessarily be determined, as also the effect of this lift on the life of the valve seats and the tendency the lift of the valves may have to raise the water in the boiler.

It is no less important that some data be collected on open and muffled valves, and in this connection, considering the tendency of the muffler to retard the flow of steam through the valve, it is of importance

that we review the work of Mr. Brownlee on the flow of steam through an orifice, which is contained in a "Report on Safety Valves" in the transactions of the Institution of Engineers and Shipbuilders in Scotland, Vol. XVIII, 1874-75, page 13. In this report Mr. Brownlee has compiled some data on the rates of discharge under a constant internal pressure, into various external pressures, upon which D. K. Clark, in his work on the steam engine, bases the following statements: "The flow of steam of a greater pressure into a receiver of a less pressure increases as the difference of pressure is increased, until the external pressure becomes only 58 per cent of the absolute pressure in the boiler. The flow of steam is neither increased nor diminished by the fall of the external pressure below 58 per cent, or about four-sevenths of the inside pressure, even to the extent of a perfect vacuum. In flowing through a nozzle of the best form, the steam expands to the external pressure, and to the volume due to this pressure, so long as it is not less than 58 per cent of the internal pressure. For an external pressure of 58 per cent and for lower percentages, the ratio of expansion is 1 to 1.624."

From the foregoing, one is led to believe that the muffler produces no appreciable retarding effect on the safety valve. The committee feels that this should be verified in present practice.

As stated before, it is essential that the amount of evaporation that the safety valves should relieve be determined. This can best be determined by applying two safety valves of known diameters and lift, which, according to the empirical formula, are known to be a little small. A third valve, of a larger diameter and set to pop at a somewhat higher pressure than the smaller valves, should be applied as a means of protection. If at any time during the test the two small valves go into action and the boiler pressure rises above the popping point, it would be reasonable to assume that the valves were of insufficient capacity. Another trial with valves of a larger diameter would no doubt prove of sufficient capacity. By changes in this manner it would be possible to apply two valves of sufficient capacity, and the diameter, lift, and form of valve being known, it would be a simple matter to obtain the amount of evaporation that the valves were called upon to relieve on the particular type of locomotive in question. It is important in this connection that the observation of pressures be very accurate, and the committee would suggest that a pressure-recording gauge be attached to the boiler to serve as a check on the observer. Suitable gauges for this work are now on the market. Perhaps the most reliable method of determining the lift of the valves would be to attach a rod to the top of the valve stem. This rod could be connected to a lift-recording gauge and also to a lift-recording mechanism, operated by a small motor, which, while recording the lift on the card, would also record the time element. This mechanism would give an accurate check on the gauge observations. It is understood of course that the lift measurements be made in the shop.

During the past few months the committee has been collecting data

from the various railroad companies in order to arrive at some definite conclusions regarding existing practices. A letter of inquiry was also addressed to the various valve manufacturers and to the locomotive builders, to whom the committee feels grateful for their assistance and the information they have so willingly furnished. The replies from some twenty railroads show that the safety valves now in use are of sufficient capacity, and on these reports the committee has based the calculations that are to follow. The records from twelve important roads show that the lift of the valves varies from 1-32 inch to 1-10 inch.

Taking the mean effective area of opening in square inches per 500 square feet of heating surface, based on existing average practice of twelve railroads, we have developed the following empirical formula:

$$A \text{ equals } \frac{0.10266 \times H.\,S.}{P}$$

Where A equals the effective area of opening of the valve in square inches, H. S. equals the heating surface of boiler in square feet, and P equals the absolute pressure, equals gauge pressure plus 15 pounds. The formula is based on an evaporation of 5.28 pounds of water per square foot of heating surface per hour, and we recommend it for use in the application of safety valves until such time as it is shown to be in error or, upon future investigation, a better one shall have been devised.

The valves of nine prominent valve manufacturers show a lift ranging from .03 inch up to .15 inch; taking an average of these lifts (0.087 inch) and working out the values for typical modern switching, freight and passenger locomotives, we give the following tabulation illustrating the application of the empirical formula:

Type of Locomotive.	Service.	Heating Surface, Square Feet.	Gage Pressure.	No. and Size of Valves.
Pacific........	Passenger.....	3500	200	3—3½-inch.
Consolidation..	Freight.......	3200	200	3—3½ "
6-wheel switch.	Yard..........	1900	200	2—3½ "

In this tabulation it will be seen that the number and size of safety valves for the Pacific and Consolidation type locomotives are the same. This is so because the committee deems it advisable and would recommend that the railway companies adopt one standard size of safety valve for all their locomotives, and not have, say, two 3-inch and one 3½-inch valve on the same locomotive. We feel that the adoption by railroads of one size of safety valve for all locomotives will bring about a uniformity that is much to be desired. The valves shown in the tabulation are assumed to have forty-five-degree seats.

In all these deductions one must bear in mind that the committee has assumed a rate of evaporation based on the capacity of discharge of the safety valves now in use, and since a vast majority of the railroads

are experiencing no difficulty with safety valves this seems to be a reasonable assumption.

F. M. GILBERT (Chairman),
G. W. WILDIN,
J. H. MANNING,
Committee.

NEW YORK, May 18, 1908.

NOTE.—*Mr. Milliken, a member of the committee, did not agree with the above recommendations, and submits a minority report as follows:*

MINORITY REPORT.

To the Members:

The writer has declined to sign the report of the committee appointed to collect data on the sizes and capacity of safety valves and to suggest methods for carrying out tests to determine the data in connection therewith, for the following reasons:

First: Because there is given a definite recommendation founded on an empirical formula, that appeals to us as not having been proven as dependable.

Second: Because a definite size of safety valves is recommended for given capacity boilers without regard to location, when the location of safety valves, to give desired results, is just as important as the size of the valves themselves.

Third: Because of the further recommendation to use but one size of valves regardless of the number that may be required on very large boilers.

Fourth: Because, while a valve of a given diameter is suggested, no maximum lift, or free discharge, is recommended.

The committee has found this a large subject, and while a very important one, it is surprising what little valuable data is available; there are numbers of formulæ, generally quite old, and the majority evidently relate to stationary practice, and you will all coincide that there is a vast difference in the requirements for safety valves for stationary boilers and modern high pressure locomotive boilers of to-day. Stationary boilers usually have large steam spaces, where valves can be conveniently and properly located, and it is seldom that the entire volume of steam being generated is held in check suddenly. With the locomotive the boiler is urged to its utmost capacity; the throttle instantly closed; the draft, caused by the speed of the engine, only partially stopped and often induced by the use of the blower to prevent the emission of smoke; hence the greater necessity of the use of correct size and properly located safety valves. Quite a number of these formulæ are worked out on a grate area basis, which is eminently wrong, because the effectiveness of the grate area is dependent on the kind of fuel used, varying from anthracite to

high grade, gas-bituminous, and even to other fuels, such as crude oils and petroleums. Other authorities use the heating surface of the boiler as a constant, and with this as a basis the evaporative efficiency of the boilers must be considered, and it is here that we feel we should be careful of our data.

The committee has used an evaporation of 5.28 pounds of water per square foot of heating surface, and tests of recently constructed boilers, as brought out by the tests at St. Louis, have given over 12 pounds, or an increase of over 100 per cent.

I think that you will agree with me that the proper location of safety valves is just as important as their size; there are numerous examples of valves located on shells of boilers, attached to contracted steam spaces, or that have been located on pipe connections, that have resulted in entrained water and fluctuation of pressure in contracted steam spaces that has resulted in destroying the valves and failure to relieve the boilers; while the same sized valves, when properly relocated, have worked satisfactorily.

In connection with reason number three, the writer objects to the use of more than two safety valves, when they can be had of sufficient capacity to relieve the boiler, believing the cost and care necessitated in maintaining them will more than offset the advantage of maintaining but one size. Each valve should be of sufficient capacity to generally relieve the boiler under ordinary working conditions; the second valve should be provided to take care of extraordinary or unusual conditions and should only come into play sufficiently often to insure its being kept in working condition. In other words, we should use two safety valves for the same reason that we use two injectors, one to supply the boiler ordinarily, the second as a relief in case of failure of the first or upon extraordinary momentary duty being placed on the boiler.

The writer feels, in view of the great importance of this subject and the small amount of absolutely accurate information that the committee has been able to gather this year, that a committee should be continued; that its scope should be increased to cover the subject of safety valves generally, muffled as well as open valves, and particularly to make recommendations, in addition to the capacity of the safety valves, for their location; that they be authorized to conduct tests to determine if any of the rules that are now in force are correct and if not to formulate such rules as will provide us all with good working basis. While the diameter by which safety valves are now usually ordered is quite important, a more important fact is the real area of outlet, and the size of this outlet will be governed not only by the foregone conclusions, but also by the pressure that the boilers carry.

Respectfully submitted,

JAMES MILLIKEN.

WILMINGTON, DEL., May 27, 1908.

THE PRESIDENT: Gentlemen, the report is before you for discussion, but as there is a minority report presented by Mr. Milliken, I think we had better have that read before proceeding. The Secretary will read it. The Secretary read the minority report.

THE PRESIDENT: Gentlemen, you have heard the minority report, which we will consider in connection with the regular report, and the subject is now open for discussion.

MR. WALSH: I move you, Mr. President, that the recommendation contained in the minority report be adopted.

(Motion seconded.)

THE PRESIDENT: Is there any discussion on this motion?

MR. GAINES: I would like to suggest to the Association as a whole that emphasis be laid on the one recommendation they make of tests, as considering both the original report and the minority report, it is very evident there is a considerable lack of data on the whole subject. It is an important subject, and there are some very valuable points brought out in both reports, and I think to make the report next year valuable, if it is a possible thing, we should have some tests to determine the proper location, to determine the best or most desirable amount of lift, and to develop formulæ and if there is any possibility to have a series of tests, I do not know of any one subject that would benefit the Association as a whole more than to get some accurate data on this subject.

MR. NELSON: It might be of interest possibly at this time to state that during the St. Louis test it was necessary for us to have a calibration of all safety valves used on the boilers included in those tests, because, under some conditions, it was difficult to prevent the safety valves from blowing, and we made a calibration of the valves in order to determine the amount of water lost per second. We did not keep a record of the names of these valves, but the average amount of water passed per second by all the valves tested at St. Louis was 1.29 pounds, and since we have had the plant at Altoona we have found it to be 1.6 pounds of water per second passed by the safety valve.

We made a test very recently, since this report was written,

to see what the condition would be with the locomotive running at about the capacity of the boiler, and suddenly shut off, and we found under those conditions that the four-inch safety valve which we are using passed 2.4 pounds of water per second.

MR. PECK (C. & W. I.): In my experience, especially in sections of the country where we have bad water, I think it is necessary that the boilers should be relieved very gradually. I have known many times where an engine would stall on the hill on account of the engine blowing off, with bad water, and the train would come to a standstill. I think the committee should take into consideration the use of different kinds of water in the test, as I think if the boiler is gradually relieved, and gradually shut off, it is much better than when relieved instantly, and shut off instantly, on account of the bad condition of the water. I also think a gradual relief better for the safety of the boiler.

MR. GILBERT: I can not see that there is any necessity of going into any elaborate tests to verify laws that have been repeatedly checked. The only important point at issue, as I see it, is the question — what constitutes the most exacting conditions for the safety valves? The report simply lowers the high points and raises the low points of existing practice, which seems to have given pretty good satisfaction. There is danger that boilers equipped with a certain number of valves, of certain sizes, which have a certain outlet, may have their valves changed, so as to get valves of the same nominal diameter and possibly not more than one-eighth of the outlet of the original equipment, and, under these conditions, we may get into some trouble, but if we can establish a relation between the work to be done, and the outlet which is to do it, I think no serious trouble need be apprehended. It seems to me unnecessary to go back and verify laws governing the flow of steam which have been so repeatedly checked. Further, I would like to say that if this committee is continued, and it is expected to accomplish anything, it will be necessary that we get a more prompt response from those in position to furnish information. It appears to me that the railroad companies had to dig up the information, and in many cases it was only fragmentary when we got it, important items being omitted.

MR. VAUGHAN: I would ask Mr. Nelson if he found any

difference between different styles of safety valves in the rate of discharge?

MR. NELSON: We have no information in regard to that, because, as I stated a moment ago, we did not keep a record of the names of the valves on the engines tested in St. Louis, and up to this time we only tried one valve which we are using, but with 2.4 pounds per second, that would mean with two such valves, which we use, it would correspond to 6.54 pounds per square foot of heating surface, whereas the committee recommends 5.28, so that the committee's recommendation is very close, probably, to what is necessary.

MR. SANDERSON: I would ask Mr. Nelson if in that calibration of the test engines at St. Louis, without any reference to the names or makes of the valves, he did not find great variation in the capacity of the valves of the same size? It would be interesting to the members to know that, to show there is need of much more thorough investigation into this subject on that account. The nominal size of the valve does not always govern its real capacity.

MR. NELSON: There is a variation in the amount of steam passed by the different valves at St. Louis, but we did not take the diameters of the valves, so that our data are not reliable from the standpoint you speak of.

MR. VAUGHAN: Is there a difference?

MR. NELSON: I have the figures. They range from .347 pounds per second, to 2.95 pounds per second. I think it is largely a matter of the ideas of the builders in regard to the proper relief for the boiler.

THE PRESIDENT: Are there any further remarks on this subject? If not, we will put the question. It is moved and seconded that the recommendations in the minority report be adopted. (Carried.)

THE PRESIDENT: As Mr. Vauclain is not yet here, we will take up the next report. Revision of Standards, Mr. W. H. V. Rosing, chairman.

Mr. Rosing read the report.

REPORT OF COMMITTEE ON REVISION OF STANDARDS.

To the Members:

We have entertained the subject of revision of standards for this Association in the order they are published in the Proceedings for 1907, and desire to submit the following:

SCREW THREADS, BOLTS AND NUTS.

We recommend that the standards as published on pages 353 and 354 be continued without change.

In the formula, on page 354, for diameter of screw at bottom of thread, there should be a decimal point after the 1 in the numerator of the fraction, instead of a comma.

In the table on page 355, we recommend the word "hexagon" be prefixed to the word "nuts" in the heading of the second column, and "bolt heads" in the heading of the third column, and that the table be continued from 2 inches to include 3½-inch sizes, as follows:

SCREW THREADS.				HEXAGON NUTS.				HEXAGON BOLT HEADS.			
Diam. of Screw.	Threads per Inch.	Diam. at Root of Thread.	Width of Flat.	Short Diam. Rough.	Short Diam. Finish.	Thickness Rough.	Thickness Finish.	Short Diam. Rough.	Short Diam. Finish.	Thickness Rough.	Thickness Finish.
$2\frac{1}{4}$	$4\frac{1}{2}$	1.962	.0277	$3\frac{1}{2}$	$3\frac{7}{16}$	$2\frac{1}{4}$	$2\frac{3}{16}$	$3\frac{1}{2}$	$3\frac{7}{16}$	$1\frac{3}{4}$	$2\frac{3}{16}$
$2\frac{1}{2}$	4	2.176	.0312	$3\frac{7}{8}$	$3\frac{13}{16}$	$2\frac{1}{2}$	$2\frac{7}{16}$	$3\frac{7}{8}$	$3\frac{13}{16}$	$1\frac{5}{16}$	$2\frac{7}{16}$
$2\frac{3}{4}$	4	2.426	.0312	$4\frac{1}{4}$	$4\frac{3}{16}$	$2\frac{3}{4}$	$2\frac{11}{16}$	$4\frac{1}{4}$	$4\frac{3}{16}$	$2\frac{1}{8}$	$2\frac{11}{16}$
3	$3\frac{1}{2}$	2.629	.0357	$4\frac{5}{8}$	$4\frac{9}{16}$	3	$2\frac{15}{16}$	$4\frac{5}{8}$	$4\frac{9}{16}$	$2\frac{15}{16}$	$2\frac{15}{16}$
$3\frac{1}{4}$	$3\frac{1}{2}$	2.879	.0357	5	$4\frac{15}{16}$	$3\frac{1}{4}$	$3\frac{3}{16}$	5	$4\frac{15}{16}$	$2\frac{1}{2}$	$3\frac{3}{16}$
$3\frac{1}{2}$	$3\frac{1}{4}$	3.100	.0384	$5\frac{3}{8}$	$5\frac{5}{16}$	$3\frac{1}{2}$	$3\frac{7}{16}$	$5\frac{3}{8}$	$5\frac{5}{16}$	$2\frac{11}{16}$	$3\frac{7}{16}$

PROPORTIONS FOR SELLERS' STANDARD NUTS AND BOLTS.

We recommend that the formula for calculating the dimensions of standard nuts and bolt heads on page 356 be continued unchanged, with the exception of the equation for "rough head," which should read as follows:

Rough Head = ¾ times diameter bolt plus 1-16 inch.

This will give the same result as figured with the present equation, but will express the equation with reference to the diameter of the bolt, same as the remaining equations on that page.

SQUARE BOLT HEADS.

We recommend that the rule for calculating the square bolt heads be continued without change.

SHEET METAL GAUGE.

We recommend the type of micrometer gauge, on page 357, be continued, and that it be printed in advance of the decimal gauge which is shown on page 386.

DISTANCE BETWEEN BACKS OF FLANGES.

We recommend the dimensions shown under this item on page 357 to be applicable to steel-tired wheels, either engine truck, driver or tender wheels, and that the M. C. B. standard gauges for cast-iron wheels shown on pages 239, 240 and 241 of the M. C. B. Proceedings, 1907, be used when cast wheels are applied to engines or tenders.

This item should precede the item of driving-wheel centers and sizes of tires, shown on page 358, and the diagrams referred to printed on plates Nos. 14 and 15.

LIMIT GAUGES FOR ROUND IRON.

We recommend the figures shown in the table on page 357, and the illustration of gauges, pages 357 and 358, be maintained, with the addition of limits of measurement of iron from 1⅜ inches up to 1⅞ inches in diameter, as follows:

Nominal Diameter of Iron, Inches.	Large Size End, Inches.	Small Size End, Inches.	Total Variation, Inches.
1⅜	1.3860	1.3640	.022
1½	1.5115	1.4885	.023
1⅝	1.6370	1.6130	.024
1¾	1.7625	1.7375	.025
1⅞	1.8880	1.8620	.026

Round iron 2 inches in diameter and over should be rolled to the nominal diameter.

DRIVING-WHEEL CENTERS.

We recommend the various sizes of wheel centers given in previous report, as follows:

38 inches	44 inches	50 inches
56 inches	62 inches	66 inches
70 inches	72 inches	74 inches
78 inches	82 inches	86 inches
90 inches		

be maintained as standard.

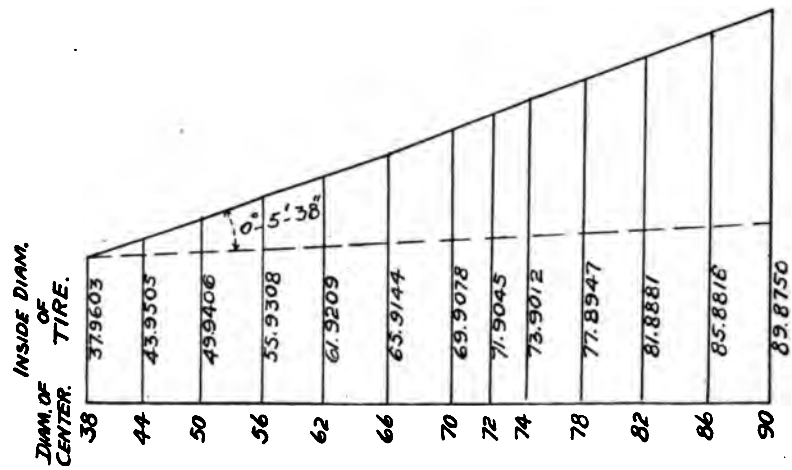
SECTION OF TIRE.

NOTE.—We recommend the section of tire for steel-tired wheels shown on Plate 1 be changed on tread to conform with the tread of wheel shown on Sheet J, M. C. B. Proceedings for 1907.

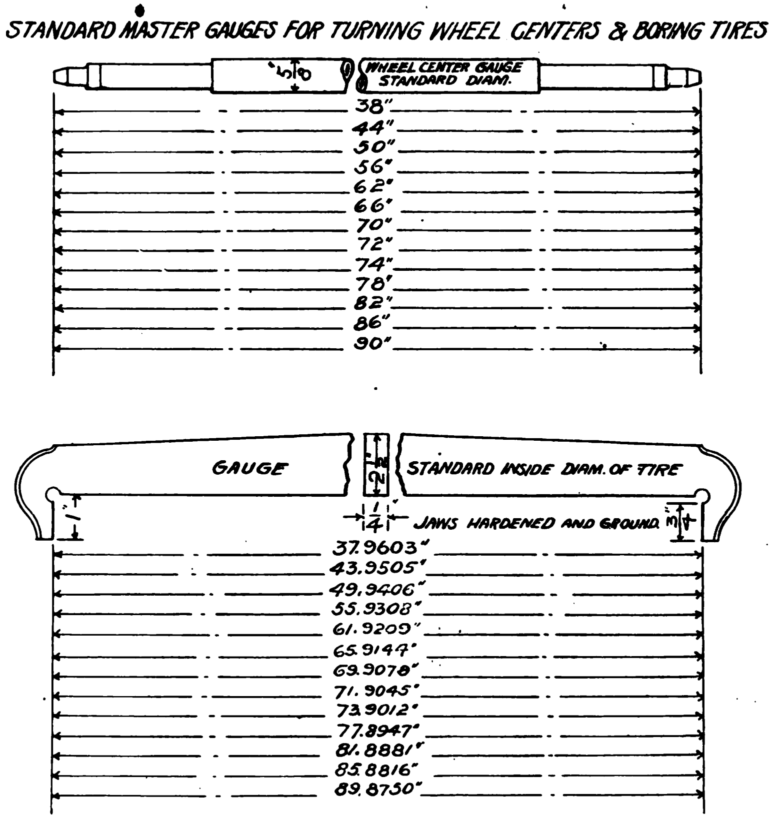
This item should follow the item of "DISTANCE BETWEEN BACKS OF FLANGES."

SHRINKAGE ALLOWANCE OF TIRES.

We recommend that the shrinkage of tires should be on a uniform and proportionate basis, and that the dimensions shown in the diagram below, allowing 1-80 of an inch per foot in diameter of 38-inch centers, and 1-60 of an inch per foot in diameter of 90-inch centers, be adopted.



We recommend the following heading for tire and wheel center gauges: "Standard Master Gauges for Turning Wheel Centers and Boring Tires," and that the illustration for these gauges be made to include the dimensions for all of the standard wheel centers and tires, and the item follow the item of "Shrinkage Allowance of Tires."



SPOKES.

We recommend the sectional spoke for driving-wheel centers, shown on page 359, be continued without change.

DRIVING-WHEEL CENTERS.

We recommend the practice for molding of driving-wheel centers, page 360, be continued without change.

We recommend the omission of the paragraph relating to thickness of flange, on top of page 361, as this will be governed by gauges recommended under the head of "Distance Between Backs of Flanges."

STANDARD METHOD OF CONDUCTING EFFICIENCY TEST FOR LOCOMOTIVES.

We recommend the method of conducting the efficiency test of locomotives, commencing on page 364, be continued without change, and that the illustrations of indicator attachments, on pages 384 and 385, be printed following the illustrations on page 367. This subject should precede Air-Brake Instruction Rules on page 400.

DECIMAL GAUGE.

We recommend that the decimal gauge, page 386, be continued without change.

BRIGGS' STANDARD WROUGHT-IRON PIPE AND THREAD.

We recommend that this subject be combined with the one following, page 387, to read as follows:

STANDARD DIMENSIONS AND THREADS OF WROUGHT PIPE.

The words "wrought pipe" in the above heading to include wrought-iron and steel pipe.

The dimensions of pipe and threads shown in the present printed table agrees with all manufacturers' list, with the exception of the actual inside diameter of the following sizes of pipe:

⅛-inch	1 inch	8 inches
⅜-inch	2½ inches	9 inches
½-inch	3 inches	10 inches

which are shown to be .001 of an inch larger in diameter than the manufacturers' list. We recommend, therefore, that the list be reprinted, and that it include 11-inch and 12-inch pipe, as follows:

DIAMETER OF TUBE.			Thickness of Metal.	SCREWED ENDS.	
Nominal Inside.	Actual Inside.	Actual Outside.		Number of Threads per Inch.	Length of Perfect Screw.
Inches.	Inches.	Inches.	Inches.	No.	Inch.
$\frac{1}{8}$	.269	0.405	0.068	27	0.19
$\frac{1}{4}$	.364	0.540	0.088	18	0.29
$\frac{3}{8}$	.493	0.675	0.091	18	0.30
$\frac{1}{2}$	.622	0.840	0.109	14	0.39
$\frac{3}{4}$	.824	1.050	0.113	14	0.40
1	1.047	1.315	0.134	$11\frac{1}{2}$	0.51
$1\frac{1}{4}$	1.380	1.660	0.140	$11\frac{1}{2}$	0.54
$1\frac{1}{2}$	1.610	1.900	0.145	$11\frac{1}{2}$	0.55
2	2.067	2.375	0.154	$11\frac{1}{2}$	0.58
$2\frac{1}{2}$	2.467	2.875	0.204	8	0.89
3	3.066	3.500	0.217	8	0.95
$3\frac{1}{2}$	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
$4\frac{1}{2}$	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.981	8.625	0.322	8	1.46
9	8.937	9.625	0.344	8	1.57
10	10.018	10.750	0.366	8	1.68
11	11.000	11.750	0.375	8	1.79
12	12.000	12.750	0.375	8	1.90

STANDARD PIPE UNIONS.

We recommend that the standard for pipe unions, published on page 388, be continued without change.

AXLES.

We recommend that this item be changed to read:

AXLES FOR LOCOMOTIVE TENDERS.

We recommend that the dimensions of axles shown in Plate 1 be made to conform to the latest M. C. B. dimensions for axles of corresponding capacity, and that Plate 1 be changed accordingly, and the text of the specification and test prescribed for axles by the Master Car Builders' Association be added.

JOURNAL-BOX BEARING AND PEDESTAL.

We recommend that the pedestal, which is for passenger cars having 3¾ by 7-inch journals and shown on Plate 14 and referred to in first paragraph under this item, be omitted from the Proceedings of this Associa-

tion, and that the journal boxes and contained parts for journals 3¾ by 7 to 5½ by 10 be made to conform to the M. C. B. standards.

We recommend that the following specifications be grouped together: For Boiler and Fire-box Steel; Locomotive Iron Tubes; Locomotive Seamless Cold-drawn Steel Tubes; Locomotive Driving and Engine Truck Axles; Locomotive Forgings; Steel Blooms and Billets for Locomotive Forgings; Foundry Pig Iron; Locomotive Cylinder Castings, etc.; Cast-iron Car Wheels, and that the present specifications for all but the last item be continued without change.

For cast-iron wheels we recommend the designs, specifications, etc., be the same as the standards of the M. C. B. Association, and that the form of contract shown on page 398 be eliminated, inasmuch as this is a purchasing, or legal matter, and not within the jurisdiction of the Mechanical Department. The M. C. B. specifications do not call for a service guarantee, and we consider it advisable to omit this item from the Proceedings, especially as many roads now have guarantees for greater mileage than shown on page 399.

FITTINGS FOR LUBRICATORS.

We recommend that the fittings for lubricators, pages 392, 393 and 394, be continued without change.

RECOMMENDATIONS.

We recommend that the recommendations on page 397, relative to mileage allowance for engines in various classes of service, be continued without change.

AIR BRAKE AND TRAIN AIR SIGNAL INSTRUCTIONS.

We recommend that these instructions be continued without change.

GENERAL QUESTIONS REGARDING THE USE OF AIR BRAKE AND TRAIN AIR SIGNAL.

We recommend that the questions for examination be continued without change.

CODE OF APPRENTICESHIP RULES.

We recommend that the code be continued without change.

The committee desires to recommend:

1. That all names of manufacturers on gauges and the like be omitted.

2. That a committee be appointed to investigate and submit tables showing limits of pressure within which wheels for locomotives and

tenders should be pressed on for different sizes of journals, kinds of material in wheel centers and axles, and whether wheels have tires on or off.

3. That a committee be appointed to recommend a standard for safety appliances for locomotives and tenders, in line with the investigation being made by the Master Car Builders' Association for cars.

Respectfully submitted,

W. H. V. ROSING,
T. W. DEMAREST,
C. B. YOUNG,
Committee.

ST. LOUIS, MO., March 24, 1908.

THE PRESIDENT: Gentlemen, this subject is now before you for discussion, and if there are any corrections to be made they will be considered, and after the details are settled it should then go to letter ballot.

MR. SELEY: I beg to compliment the committee on its report, having had some experience in a similar line of work. I have one suggestion. Would it not be better, with reference to the naming of M. C. B. standards to state that the latest M. C. B. standards are intended in all cases, instead of specifying the M. C. B. Proceedings of 1907? I think that the standards of the Master Mechanics' Association should conform to the M. C. B. standards, and I would like to bring that point up. It may be that I am a little critical in this, but I believe it would be better to express them as the latest M. C. B. standards.

MR. E. A. MILLER: On page 8, standard pipe unions, they recommend that the standard for pipe unions published on page 388 be continued without change. The difficulty that we find is that the manufacturers of pipe do not work to the same standards, and we don't get any two pipe fittings of the same size, and when it comes to repair work, it brings about a good deal of inconvenience and waste. What I would like to see is an effort made to bring the pipe men to standard sizes in the making of pipe fittings.

MR. GAINES: I want to call attention to one of the recommendations at the bottom of page 9. I believe that the committee

on this subject — we agreed to change the present code of rules to the report of the Committee on the Apprenticeship System.

THE PRESIDENT: Any further discussion on this subject?

MR. VAUGHAN: Is there any change in the recommendation for shrinkage allowance of tires? You practically have adopted the present standard.

MR. ROSING: The standard now is to allow 1-80 of an inch per foot for tires under sixty-six inches and 1-60 of an inch for all wheel centers over sixty-six inches. We rather thought this to be a radical step, so to speak, and considered a uniform scale which is shown on the diagram, taking the dimensions recommended for the smallest wheel and those for the largest wheel and proportioning them for all other wheels accordingly.

MR. VAUGHAN: That gives you as many sizes as you have wheels.

MR. ROSING: Yes, sir. Inasmuch as those dimensions are all expressed in thousandths or ten thousandths of an inch, and we thought it would be just as easy to make a gauge to one figure as another. So far as shop practice is concerned, it will be always done by a gauge, and the mechanic turning the wheels will not have any occasion to make any measurements himself.

MR. SANDERSON: There are a number of distinct recommendations on the part of the committee that need some action in the form of motions. I would like to ask Mr. Rosing if he would call them up, paragraph and page, as they come in the report, so that we can take action on them as the convention sees fit.

MR. ROSING: I had in mind that it would be submitted to letter ballot.

THE PRESIDENT: You understand, Mr. Sanderson, the idea at present is to offer any suggestions or objections to these items as they appear in the printed matter and then discuss them, if there are, and finally submit the whole to letter ballot; and I would say in that connection that it would be advisable for the secretary of the committee to modify some of the phraseology there so that it will be comparable with former reports.

Mr. Rosing: The committee no doubt would be glad to accept Mr. Seley's recommendation and it was our view that in referring to any of the Master Car Builders' Standards, we use the very latest, and anything that has occurred at this convention of the Master Car Builders should be embodied in these Proceedings, instead of referring to the 1907 report.

The President: Any further suggestions? If not, a motion to refer the matter to letter ballot will be in order.

Mr. Wildin: I move the matter be referred to letter ballot.

Motion seconded.

Mr. Sanderson: There are two recommendations there in which they recommend the appointment of committees. Could that be left to the Executive Committee without action?

The Secretary: Yes; that will be taken care of.

The President: We will now take up the discussion and report of the Committee on Subjects.

The Secretary here read the report of the Committee on Subjects.

REPORT OF COMMITTEE ON SUBJECTS.

To the Members:

Your committee, appointed to suggest subjects for the noon-hour discussion at the 1908 convention, also subjects for committee work for the 1909 convention, begs leave to report as follows:

TOPICAL DISCUSSION.

1. Alloy Steel. Results from use in machine tools and special cutters.

To be opened by Mr. J. A. Carney.

2. The Smoke Nuisance. What is best method of preventing it?

To be opened by Mr. H. T. Bentley.

3. Proper and best method of caring for hand lamps, markers and classification of lamps on Locomotives.

To be opened by Mr. D. J. Redding.

4. Use of non-combustible engine house jacks of wood or other material.

To be opened by Mr. R. D. Smith.

5. Standardization of Locomotive parts.

To be opened by Mr. T. W. Demarest.

6. Advisability of using ball joint unions for air and steam pipe connections on locomotives and tenders.

To be opened by Mr. C. B. Young.

COMMITTEE REPORTS.

1. The organization best suited to obtain economical results in maintenance of locomotives.

Le Grand Parish, H. D. Taylor, D. J. Redding, A. Forsythe, S. J. Hungerford, H. W. Jacobs.

2. Driving pressure for firebox rivets and the advantage of avoiding seams in locomotive crown sheets.

W. F. Kiesel, J. H. Manning, W. A. Robb, H. H. Maxfield, G. Wagstaff.

3. Use of plug and ring gauges for all important fits.

R. N. Durborow, A. Stewart, L. H. Turner, H. B. Ayres.

4. Ash pits and ash handling plants; the best and most efficient arrangement.

H. S. Hayward, W. Manchester, F. H. Clark, John Howard, H. M. Curry.

5. Rolled Steel Wheels.

A. S. Vogt, H. Bartlett, J. E. Muhlfeld, C. H. Quereau, G. W. Wildin.

6. Standard Rules for Testing Boilers and Stay Bolts.

J. T. Wallis, T. A. Foque, M. E. Wells, M. H. Wickhorst, W. C. A. Henry.

7. Standard Limits Governing the Wear of Locomotive Tires, as concerns height and thickness of flange and depth of channeling.

E. D. Bronner, Robt. Quayle, R. K. Reading, C. E. Fuller, J. T. McGrath.

8. Advantages of water purification as a means of decreasing cost of locomotive repairs and reducing failures on the road.

W. C. Arp, H. Stillman, G. H. Emerson, R. D. Smith, E. B. Thompson.

9. Investigation as to the most desirable composition of material for locomotive driving wheel tires, and adoption of standard grades for various classes of service.

T. W. Demarest, W. R. McKeen, J. A. Carney, W. A. Nettleton, F. M. Whyte, C. B. Dudley.

INDIVIDUAL PAPERS.

1. Heat Transference of Tubes and Plates.

Prof. Charles Edward Lucke, Columbia University.

2. Crane Hooks; Results of Exhaustive Experiments and recommendations as to design.

Prof. Walter Rautenstrauth, Columbia University.

C. A. Seley (Chairman),
D. F. Crawford,
L. R. Pomeroy,
Committee.

The Secretary: I move that this report be referred to the Executive Committee for consideration when it makes up the program for next year.

Motion seconded and carried.

Mr. Henderson: Mr. President, it seems that there has recently been a law passed regarding the type of ash pan to be used on locomotives, and in order to comply with the new law, which I believe is to make it unnecessary for the men to get under the engine, would it not be well for a committee to report on that subject? I would like to move that that subject be added to the list.

Mr. Wildin: I don't believe it would be of any use to appoint a committee because we must have the ash pans on before the committee can report. We only have until January, 1910, to complete the work.

Mr. Manchester: I believe it would be a wise proposition for this convention to instruct the Executive Committee to take up with the American Railway Association the question of how far we should go into the matter of investigation by this Association in accordance with the proposition suggested by Mr. Henderson. Unless the American Railway Association knows of some way in which this matter may be handled otherwise, I believe it would be well for this Association, through its Executive Committee, to commence work as early as possible on this proposition. In order to get this matter before the convention I will second Mr. Henderson's motion.

MR. SELEY: I will support the seconder of that resolution if he puts it with the understanding he has already expressed in regard to the reference to the American Railway Association. I believe we must have the information and the way that the law was put through.

MR. HENDERSON: I will accept that as an amendment, Mr. President.

Motion seconded and carried.

THE PRESIDENT: We will take up one of the topical discussions now which is entitled, "Standardization of Locomotive Parts," to be opened by Mr. G. R. Henderson.

TOPICAL DISCUSSION—THE STANDARDIZATION OF LOCOMOTIVE PARTS.

MR. G. R. HENDERSON: Mr. President, the subject of the standardization of equipment is not very new in itself. We have been working, and especially the M. C. B. Association, on the standardization of parts for cars a great many years. But the principal object to be gained by the standardization of parts on cars was on account of the interchangeability of equipment, so that repairs to cars on foreign lines could be made quickly with the least delay.

When we come to the question of locomotives, the object to be attained is somewhat different. Locomotives are rarely interchanged on different roads, and the principal points which we hope to gain are in the decreased cost in the stock we must carry for repair parts, and the convenience and advantage of having only a few parts. It goes without saying that any road which has a number of locomotives is bound to carry parts to keep the locomotives in service and make necessary repairs promptly, so that the principal thing in connection with locomotive work is to reduce the stock, and by legitimate means, giving this careful thought, a great deal can be accomplished in keeping down the amount of store-house stock.

It would seem at first glance, that it would be impossible to standardize locomotive parts to any very great extent, on account of the different sizes and types of engines which we have to

perform the work, and that if a design was suitable for one locomotive, or some parts of a locomotive, that an engine of different size and different type could not use the same parts profitably, that is, if they were strong enough for the engine of large cylinder they would be too heavy for the engine with a small cylinder, but we must remember that there are many details to which these remarks do not apply, and if we consider such items as pilots, headlights, whistles, sand boxes and a great number of other parts, which are entirely independent of the size and type of the engine, we can see at once that we can do a great deal in the way of standardizing.

Some roads have adopted the practice of introducing one or two types of pilots on the different classes of engines. That means much in the way of keeping down stock, reducing the cost of material, and the space occupied by it.

I was called upon recently in connection with my work to arrange for some locomotives for roads quite a distance from the base of supplies — they are in the Oriental tropics — and while they were at first using locomotives with cylinders 17 by 24, some later engines were built with cylinders 15 by 18. It was a narrow-gauge road. We found by going into the details that we could use the same cross-heads on both engines, except as to the piston-rod fit, the smaller engine (cylinder) piston rod requiring a smaller fit in the cross head, otherwise they were the same. We found that we could use the same driving box, on a smaller axle, by simply making the brass a little thicker so that it could be bored out for the small engine, and carried in stock that size, and if the box was needed for the engine with the larger axle, ½-inch diameter greater, we could simply rebore the brass for the large size. We can carry one driving box in stock for both classes of engines.

The same thing applies in the case of shoes and wedges with same outside dimensions, but the frames being different in thickness it was simply a question of planing out so as to be suitable for the greater width of the frame.

The locomotives themselves can be standardized under the same arrangement. What I mean is, that instead of having many types of locomotives suitable for different classes of service I

think the best policy is to have one or two types, and stand the criticism of having a heavy locomotive on a short train, which people not fully possessed of the facts in regard to the situation, may make, and have the locomotive of a size so that they will handle any trains that they may be put on. If you have half a dozen heavy passenger trains, and have half a dozen light passenger trains, and try to run the locomotives proportional to each, some time you will get in a place where the light engine will be called upon to haul a heavy train and the light engine will not be able to perform the service and take the train over the road. I think it is better to have the locomotives heavy enough to carry the heavy service, even if occasionally they are used for the lighter trains. This matter must, of course, be construed in relation to the purchase of new locomotives. Most railroads have enough old locomotives and light equipment, for them to use, and they must put them in the light trains.

I think there is a great deal to be said in relation to the matter of having as few varieties of locomotives on a railroad as possible. I think it is a question of common sense, just as much as engineering ability, and while, no doubt, it is perfectly proper to design a locomotive or any piece of machinery with the idea of the work it has to do, yet in a railroad we must use common sense as much as engineering ability, and that is the only way we can keep down supply parts, and thus reduce operating expenses as relates to the cost of repairs, and much economy can be secured by eliminating the necessity for the maintenance of a large stock for repairs.

THE PRESIDENT: There are some good suggestions offered by Mr. Henderson, and I think the subject which he has opened is well worthy of considerable thought and discussion.

Regarding the use of the same size of driving box for the same classes of engines, within reasonable limits, and the same size driving brass, that is quite feasible, and it is also possible to use wedges, with a little extra stock in them, in preference to carrying a large variety of extra parts.

With reference, however, to the matter of using one or two types of locomotives, which could be made to answer all purposes of the railroad, I am rather inclined to think I would have

to differ from Mr. Henderson on that point, especially in districts where there is a great variety of service. I used to feel that we should confine ourselves to one or two classes of engines, but experience has demonstrated that it is necessary to have a good many classes; there is so much of a special character about the work that in some districts the different classes of engines are required.

MR. VAUGHAN: I am a great believer in standardizing locomotives, and it has been my good fortune to do it about the way I think it ought to be done. When I went to the Canadian Pacific Ry. we had to get up a new line of engines, and the first engine we had to get up was a consolidation, and we adopted a 21 by 28 cylinder, with 57-inch wheels.

We are rather fortunate in having a very large section of our road, which is, of course, a very long road, although the traffic is small, with a fairly uniform bridge limit. We have for years been trying to get as uniform a bridge limit as possible over certain sections, and have got it over perhaps three thousand miles of main line to-day. We are now preparing for a slightly heavier bridge limit, which is gradually being worked in in one section after another; so that in future it will be necessary to design a heavier class of power which will work on our newer section.

After the consolidation we worked up a ten-wheeler with the same cylinders, and after that two types of Pacific type engines with different size of driving wheels, and hump switcher, and we built some ten-wheelers with fire boxes for anthracite coal, as well as using the normal fire box for bituminous coal, and these engines are working from Vancouver down to St. John, New Brunswick, the whole way across the continent, so you see it is possible to get one type of engine which will work in fairly dissimilar conditions. There are only two sizes of engines, one three inches higher saddle than the other, same rod brasses, same driving boxes, same throttles, rockers, and with practically the same details right through the whole series, and I can say that it has been of the greatest possible convenience to us to know that we have a class of power such that we do not care how the Transportation Department distributes it, we do not have to worry about sending castings from one division to

another to fit the engines that happen to be put on that division, and we have a line of standard parts that go on practically every engine. In that connection I wish to say that I believe thoroughly in having all these little alterations worked out in a thoroughly well equipped drawing office.

It is frequently the case that we think something is giving trouble that we have got to take immediate action, and that we must allow our shop force to go to work and get up something new. Well, I believe if the thing has run for a year or two, you can afford to let it run for another month, while the drawing-office staff can get out their drawings and see what effect any proposed modifications will have on your future work. I have seen several cases where an imperfectly considered alteration has led us to a good deal of trouble. I have seen changes made in forty or fifty engines, and then it was discovered that with a little more care or thought, it would have been possible to design the alteration so that instead of having to redesign it, after having made alterations on some engines, you could have designed it properly in the first place so as to have carried it through the road and made a standard of it. That means that you must allow this work to be done in the drawing office. It may take a little longer to have this done, but the result will be more satisfactory. Of course, you hear the shop men say that they never get anything out of the drawing office, but, in the long run, it pays to do the thing right.

We are, perhaps, singularly fortunate in being able to carry through a set of standards like that, but I think one of the reasons is we take a year to design a new engine. While we have had every assistance from the builders, and frequently receive valuable suggestions from them, yet at the same time any drawing that comes from the builders is threshed over thoroughly while in our own drawing office, and we proceed very slowly in making these modifications and alterations so that we are not getting a new and slightly heavier engine with each new lot we buy, and new patterns that do not suit us.

I believe in the railroad company doing its own locomotive designing to get down to a proper standard, and endeavor to lay out plans for the future regarding their locomotives. We

have been engaged for the last year in getting up a heavier engine to our standards, and I believe we shall make our new standard twenty per cent heavier than the old one, to take the place of existing power, and make it possible to use such heavier parts as we find it necessary to introduce through a new line of locomotives. I believe that is the proper way to do it.

MR. CURTIS: If we could bring out a standard locomotive, I would be one of the first to say hallelujah. I think all roads are endeavoring in their equipment to bring about four or five different standards for the different classes of service, but to look at the situation as it really is, we have no standard service, or conditions, and how are we going to make a standard locomotive to be economical, and have one kind of locomotive to meet so many kinds of service?

As Mr. Vaughan has said, he is blessed with having bridges of a uniform strength; other roads are not so blessed; the bridges are of different strengths, and the management demands the largest locomotives you can use over these bridges, and you have to do the best you can with the weight allowed.

I have also noticed in regard to standardizing locomotives that a great many roads endeavor to standardize their old locomotives. I think a large amount of this work is a mistake, outside of standardizing the cylinder cocks and a few of the cab appliances. I think it is a mistake to keep changing the odd locomotives to match the latest standard. I think many of you have had the experience where you had ten locomotives and endeavored to change them to a standard, and that you found that there were four or five which were changed, and the other fifty per cent were never changed, and they ran as they were until the day they went to the scrap pile, and instead of having ten engines alike, in that case you only had four or five.

I hope we can get near enough to a standard so that we can change one part of a union or coupling on a pipe from one to another, thus avoiding the necessity of throwing the whole union away on account of a different-sized thread or nut. Our standards of the Master Mechanics' Association are not lived up to in the purchasing department, and if they were I am

satisfied it would benefit us a great deal in our locomotive repairs.

MR. G. W. WEST (N. Y. O. & W. Ry.): I think with Mr. Curtis there is a limit to standardizing locomotives from economical standpoints. I was Master Mechanic on one of the Trunk lines some years ago that undertook to standardize pilots — the engines were equipped with driving wheels 44 to 72 inches in diameter, and I venture to say that the experiment of standardizing those pilots cost more than they would have saved by the change, in the life of the railroad, and they had pilots which looked as if they had picked them up along the road and used as a makeshift.

MR. WILDIN: In regard to this matter of standardizing locomotives, I do not think it is necessary to throw away a part of a locomotive which is in good condition simply to apply the new part to make the locomotive standard; but when you have to renew the part, I do not see why you should not put on the standard. The man who does the work of standardizing your equipment, and expects every time an engine comes into the shop, to apply new parts to make the engine standard, where these parts are not really worn out, will make the cost of standardization very high. Of course, when he is compelled to renew a part it should be done with a standard design, and if the changes are worked out in the drawing-room, as was suggested by Mr. Vaughan, the expense to the company is not any considerable amount. I know that pilots can be standardized from experience. We have a standard pilot on the New Haven road to-day and we have driving wheels from 79 inches down to 47 inches.

MR. GAINES: I think Mr. West has hit the matter right. I do not think we ought to attempt to take a lot of old engines and try to standardize them. Yet, take as an instance, a case where we have got to apply driving boxes to these engines, if at the same time we can apply the standard brass, standard eccentric, or standard eccentric strap, we are money ahead, because on most of the roads, you have some shop where you are attempting at least to manufacture some of these standard parts, and doing it by gauges and jigs, and trying to do it economically,

and the more of this standard material we can manufacture at one place and utilize all over the road, the better it will be and the cheaper we can get our output. While we, do not want to throw away any good material, yet when an engine comes in for repairs to certain parts, I think it is policy to apply the latest standard parts which are ordinarily used in conjunction with the new part applied. That is good in another way. Take the question of eccentrics and eccentric straps, probably ninety per cent of the old equipment was made of cast iron, and in passenger service particularly, the cast-iron eccentric strap is liable to give trouble. On our newer power, we put on something heavier and better and you get the advantage of stronger material.

THE PRESIDENT: Mr. Flory, will you kindly explain something of what the practice is on the Central of New Jersey in regard to making one standard go as far as possible?

MR. FLORY: On the Central R. R. of New Jersey we have established standards for almost every part of the locomotive that can be standardized, driving box, eccentrics, eccentric straps, and a large number of other things. It is our practice to put on standard parts when the other parts require renewing, either at the main shops or at the repair points. There have been some cases where the parts have been of weak design, and we have renewed them and put on standard parts, in some cases where the old parts were not worn out. That is, I think, very important, and I believe it is good practice to put on the standard parts whenever occasion requires.

MR. JOHN A. PILCHER (N. & W. Ry.): The railroad with which I am connected has been engaged for something like fifteen years in doing the very work which is under consideration now, that of standardizing locomotive parts, and it is surprising to what extent it can be carried, provided each individual item is thoroughly studied in the drawing-room before the standard is made.

As to the question of driving boxes. With the exception of a very few old locomotives we have probably only two types of locomotive driving boxes to cover the whole road. As to the question of pilots — there is only one pilot in use covering the

whole road, while the driving wheels on the locomotives vary from about forty-five inches to about eighty inches in diameter. This pilot has been in use for eight or nine years.

The procedure is to notify in regard to the adoption of the standard, and to authorize the change whenever the part has to be repaired, not throwing away any parts that are good for service, but changing to the new standard when the parts have to be renewed. This practice has been carried out in connection with boiler fittings, cylinder cocks, cross heads, and various other parts of locomotives, and has resulted in a large reduction of stock necessary to be carried in the Store Department.

Mr. Vaughan has very forcibly pointed out the evil of allowing the shops at various points to make changes without authority. We have also had some experience in this line; changes are made without any record being kept, and when later on it is necessary to know the exact construction of some detail it becomes necessary to send some one a long distance to make the necessary measurements and get the needed information. This is because some one has made a change without authority and without keeping a record.

One of the Master Mechanics of our road spoke to me here this morning about a certain shop foreman who undertook to settle for himself the amount of shrinkage for a driving-wheel tire, disregarding the standard the road had been using for a number of years, and which had proven to be very satisfactory. The Master Mechanic was very much upset by the procedure. Mr. Henderson was with this road when this particular standard was established, and it has not been changed in any manner since it was originally established, showing that if proper consideration is given to such matters at the proper time the design made becomes permanent, and the work satisfactory, eliminating the necessity of bringing it under consideration the second time.

Mr. Seley: I think there is no limit to which standardization can be carried with benefit, with horse-sense methods in the drawing office and on the road, and I thoroughly endorse the remarks of the First Vice-President and Mr. Pilcher.

There is one point that has been brought to my attention by the manufacturers, particularly of locomotive specialties, and

that is, that they are required by different roads to carry almost a different standard of their apparatus for each road, in the way of fastenings and attachments and connections for the locomotive. A very largely decreased cost in these plants in the matter of saving on bills for supplies and stock carried could be brought about if standards could be more generally adopted.

MR. E. A. MILLER: It is, no doubt, desired by those in charge of motive power equipment to maintain standards, so far as possible; however, the locomotive has undergone many changes in the last few years, and will undoubtedly undergo many more changes before the highest efficiency is attained.

The locomotive is expected to haul larger tonnage per train, the boiler pressure has been increased, Walschart valve gear, superheaters and many other changes, affecting practically the entire detail of the locomotive, are being made, so that it may be good judgment to depart from standards of last year, for something new and better for this year. The man is fortunate who is sufficiently wise and capable of the management of motive power affairs to be able to depart from old standards, when in so doing the efficiency and economy of the locomotive is the result.

THE PRESIDENT: Is there any further discussion on this question? If not, we will ask Mr. Henderson to close the discussion.

MR. HENDERSON: I do not believe there is much to be said in conclusion. I think the remarks which have been made by the gentlemen here have been along the same lines as my suggestions, and I do not think there are any special comments to be made.

On motion the discussion was closed.

THE PRESIDENT: We will take up the next topical subject, No. 2, "The Advisability of Using Ball Joint Unions for Air and Steam Pipe Connections on Locomotives and Tenders," to be opened by Mr. C. B. Young.

TOPICAL DISCUSSION—USE OF BALL JOINT UNIONS FOR AIR AND STEAM PIPE CONNECTIONS ON LOCOMOTIVES AND TENDERS.

MR. C. B. YOUNG (M. E., C. B. & Q. R. R.): Ball joints in the air and steam piping of locomotives are advisable both from a service and an economy standpoint. A joint with a flat gasket of rubber, or composition containing rubber, is liable to leak, owing to the vulcanization of the rubber when subjected to heat in steam pipes, or it becomes softened by the oil in air pipes and leaks soon develop through the joint. With ball joints made with metal against metal these troubles are entirely overcome. With a flat joint a gasket has to be kept in place while the coupling is being made, and occasionally this gasket doubles up or falls out without being noticed. In a difficult place one man can not manage to hold a light, see that the gasket is in place and make a coupling.

A ball joint does not have these troubles; as there is no gasket to put in, it is more easily applied than a flat joint, and in case the piping is not perfectly in line, a ball joint can easily be put together when it would be exceedingly difficult to connect up a flat joint or to make it steam or air tight.

There are a number of ball joints on the market, several of which are satisfactory. These are of two styles; those with the brass seat loosely fitted, and consequently likely to be lost out, and those which have it permanently secured or formed from one piece of the joint. For joints which are seldom broken the former is satisfactory, but for joints which are frequently broken, a ball joint with permanent seat should be selected. One of the most troublesome joints on an engine is the flat gasket joint in the air-pump discharge pipe next to the pump. Owing to the high temperature this gasket soon gives out. Something more than a year ago we fitted up some air pumps with ball joints at this point and have not had a leak or a case of repairs since the change was made.

A number of different designs of ball joints have been developed for connections between engine and tender in place of rubber hose for steam and air lines. Some of these have been found very satisfactory and economical. I have no hesitation in

recommending the use of ball joints throughout in the piping system of engine and tenders.

THE PRESIDENT: Gentlemen, the subject is now before you for discussion. I think it is important enough to receive some attention.

MR. CURTIS: I want to support what Mr. Young has said in regard to metal joints. I think the time has gone by for any composition joint to be used in any union or coupling on locomotives, and I hope to see the day when the manufacturers of those ball joints will endeavor to get together on a standard whereby we may have some interchangeability of at least the contour of the joint and not make it necessary when one part is damaged to throw the whole joint away in order to get a new or a satisfactory coupling.

MR. GAINES: I would like to ask Mr. Young whether he would recommend the ball joint having the two brass surfaces together or the one with the brass and iron.

MR. YOUNG: Answering Mr. Gaines, I would say that it seems to me that the ball joint with the brass seat — one brass seat, is sufficient and answers every purpose.

THE PRESIDENT: Any further discussion, gentlemen?

MR. SINCLAIR: I move that the discussion be closed.

Motion seconded and carried.

THE PRESIDENT: We will go back to the discussion of the report on Balanced Compounds. Mr. Nelson, I believe, is the chairman of the committee.

Mr. Nelson presented the report as follows:

REPORT OF THE COMMITTEE ON VARIOUS DESIGNS OF FOUR-CYLINDER COMPOUND LOCOMOTIVES IN SERVICE AND RESULTS THAT HAVE BEEN OBTAINED FROM THEIR USE.

To the Members:

Your committee was instructed to report on the various designs of balanced compounds in service, and the results that have been obtained from their use.

The Atchison, Topeka & Santa Fe locomotive No. 535, and the New York Central & Hudson River R. R. locomotive No. 3000, however, were of about equal weight, and in this respect resemble the two simple cylinder locomotives recently tested on the Altoona Plant. The attached Table No. 1 shows the principal features. P. R. R. locomotive No. 5266 was tested, using coal from the same mines as that furnished for the 535 and 3000 at St. Louis. Locomotive No. 3162 was tested with gas or high volatile coal.

It is now possible, therefore, for the first time, to make comparisons of two four-cylinder balanced compound and two two-cylinder simple locomotives, operated under testing plant conditions.

These four locomotives differed in minor particulars apart from their simple or compound cylinders, but as already stated, they were of about the same weight and tractive force.

The two two-cylinder simple locomotives are shown in outline on Figs. 912 and 1112, and their leading dimensions are given in Tables Nos. 2 and 3. No. 5266 has balanced double ported valves and the Stephenson valve gear, while No. 3162 has piston valves and the Walschaerts valve gear. Figs. 612 and 812 are reproduced from the record of St. Louis tests.

As these locomotives group themselves by results of tests very clearly according to their simple or compound cylinders, and as their boilers gave very similar efficiencies, as shown on Fig. 1, there is no inconsistency in comparing them directly on the basis of cylinder performance.

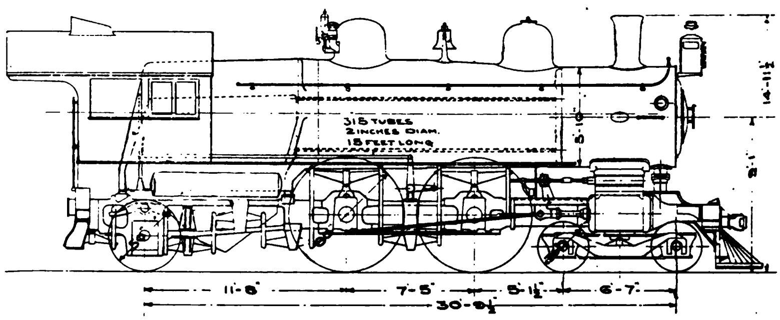


FIG. 912.— Elevation, Simple Locomotive No. 5266.

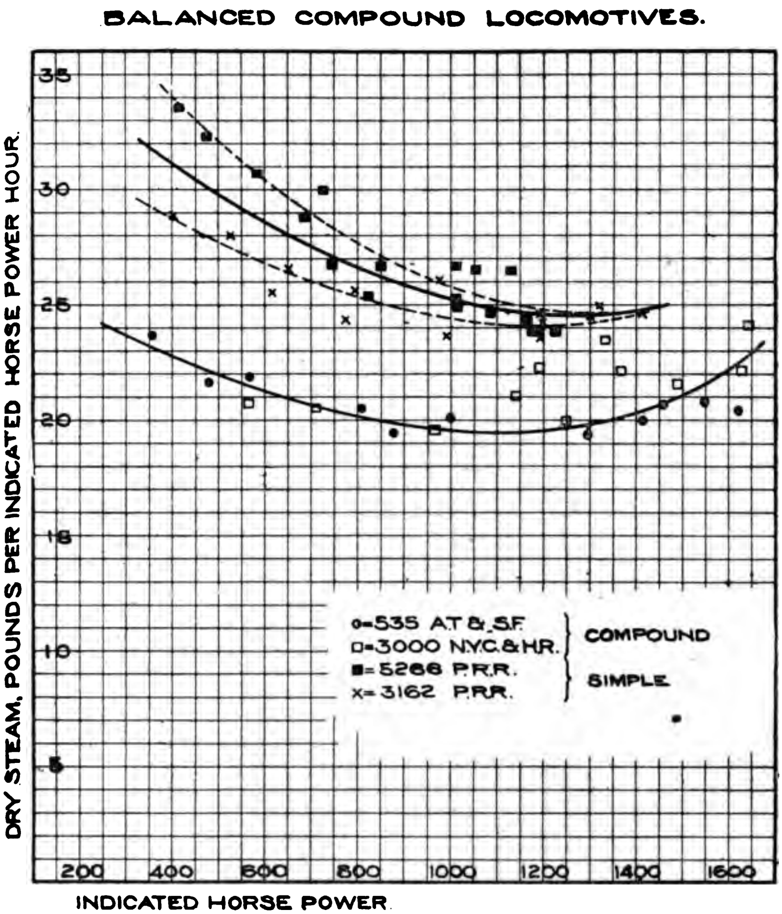


FIG. 2.— Steam Consumption, Compound and Simple Locomotives.

M. P. 804A

PENNSYLVANIA RAILROAD COMPANY

Philadelphia, Baltimore & Washington Railroad Company
Northern Central Railway Company
West Jersey & Seashore Railroad Company

TEST DEPARTMENT

LOCOMOTIVE:
TYPE 4-4-2
CLASS E2A
NUMBER 5266

TEST NOS., 901 TO 929
NOT INCLUSIVE, 18 TESTS

AVERAGE RESULTS OF LOCOMOTIVE TESTS

SUBJECT: LOCOMOTIVE TESTS WITH SCALP LEVEL COAL — ALTOONA, PA., 3-14-07.

No.	Item	Value
	DRIVING WHEELS	
1	Number of Pairs	2
2	Approx. Diameter, Inches	80
	ENGINE TRUCK WHEELS	
14	Number	4
15	Diameter, inches	36
	TRAILING WHEELS	
16	Diameter, inches	50
	WHEEL BASE, FEET	
17	Driving Wheel Base	7.42
18	Total Wheel Base	30.85
19	Gage of Wheels	4.71
	WEIGHT OF ENGINE WITH WATER AT 2D. GAGE COCK AND NORMAL FIRE, POUNDS	
20	On Truck	37167
21	" 1st Drivers	53334
22	" 2d "	56667
23	" 3d "	—
24	" 4th "	—
25	" 5th "	—
26	" Trailers	37000
27	Total	184167
28	" on Drivers	110001
	CYLINDERS	
	Diam. and Stroke, H. P.	20.5 X 26
	" " " L. P.	—
	CLEARANCE IN PER CENT. OF PISTON DISPLACEMENT	
40	H. P. Right, Head End	12.7
41	" " Crank "	12.1
42	" Left, Head "	12.4
43	" " Crank "	11.9
44	L. P. Right, Head "	—
45	" " Crank "	—
46	" Left, Head "	—
47	" " Crank "	—
	RECEIVER, CUBIC FEET	
48	Volume Right Side	—
49	" Left "	—
	STEAM PORTS, INCHES	
50	H. P. Admission, Length	20
51	" " Width	1.5
58	L. P. " Length	—
59	" " Width	—
66	H. P. Exhaust, Length	20
67	" " Width	3
70	L. P. " Length	—
71	" " Width	—

No.	Item	Value
	PISTON RODS, DIAMETER INCHES	
74	High Pressure	3.5
76	Low "	—
	TAIL RODS, DIAMETER, INCHES	
78	High Pressure	—
80	Low "	—
	VALVES	
82	Type	DOUBLE PORTED BAL. SLIDE
83	Design	AMERICAN BALANCE VALVE CO
84	Per Cent. Balanced	75.7
85	Type of Valve Motion	STEPHENSON
	GREATEST VALVE TRAVEL	
86	High Pressure, inches	7.1
88	Low " "	—
	OUTSIDE LAP OF VALVE	
90	High Pressure, inches	1.5
94	Low " "	—
	INSIDE LAP OF VALVE	
98	High Pressure, inches	NEGATIVE .15
102	Low " "	—
	BOILER	
113	Type	BELPAIRE, WIDE FIREBOX
114	Outside Diam. 1st Ring, inches	67
	TUBES	
115	Number	315
116	Outside Diam., inches	2
	Pitch " "	2.625
118	Length Between Tube Sheets, inches	179.78
119	Total Fire Area, sq. ft.	5.26
124	Boiler Pressure, pounds	205
	SUPERHEATER	
125	Number of Tubes	—
126	Outside Diam. " inches	—
128	Length of " "	—
	FIREBOX, INSIDE, INCHES	
132	Length	114
133	Width	68
137	Air Inlets to Ashpan, sq. ft.	6.3
	GRATES	
144	Type	ROCKING FINGER
145	Grate Area, sq. ft.	55.5
146	Area of Dead Grates	6.0

No.	Item	Value
	HEATING SURFACE, SQUARE FEET	
154	Of the Tubes, Water Side	2471.04
155	" " " Fire "	2162.40
156	" " Firebox, " "	156.86
157	" " Superh'r, " "	—
*158	Total, Based on " "	2319.26
159	" " " " " of Firebox and Water Side of Tubes	2627.90
	BOILER VOLUME WITH WATER SURFACE AT LEVEL OF 2D GAGE COCK	
160	Water Space, cu. ft.	338.6
161	Steam " " "	109.9
	EXHAUST NOZZLE	
162	Double or Single	SINGLE
163	Size, inches DIAM.	5.625
167	Area, sq. inches	24.85
	REVERSE LEVER	
168	H. P. Notches Forward of Center	15
169	L. P. Notches Forward of Center	—
	RATIOS	
171	Heating Surface (158) to Grate Area (145)	41.79
172	Fire Area Thru Tubes (119) to Grate Area (145)	.09
173	Firebox Heating Surface (156) to Grate Area (145)	2.83
174	Tube Heating Surface (155) to Fire Box Heating Surface (156)	13.79

*USED IN CALCULATIONS

TABLE 2.— Simple Locomotive No. 5266.

M. P. 894A
8 x 10½

[illegible]

PENNSYLVANIA RAILROAD COMPANY

Philadelphia, Baltimore & Washington Railroad Company
Northern Central Railway Company
West Jersey & Seashore Railroad Company

LOCOMOTIVE:
TYPE 4-4-2
CLASS E2D
NUMBER 3162

TEST

AVERAGE RESULTS OF LOCOMOTIVE TESTS

TEST NOS., 1116 TO 1133
NOT INCL. 1108, 1111, 1112, 1121

SUBJECT: LOCOMOTIVE TESTS WITH GAS COAL — ALTOONA, PA., 1-15-08

No.	Item	Value
	DRIVING WHEELS	
1	Number of Pairs	2
2	Approx. Diameter, inches	80
	ENGINE TRUCK WHEELS	
14	Number	4
15	Diameter, inches	36
	TRAILING WHEELS	
16	Diameter, inches	50
	WHEEL BASE, FEET	
17	Driving Wheel Base	7.42
18	Total Wheel Base	30.78
19	Gage of Wheels	56.13
	WEIGHT OF ENGINE WITH WATER AT 2D. GAGE COCK AND NORMAL FIRE, POUNDS	
20	On Truck	32833
21	" 1st Drivers	61400
22	" 2d "	60467
23	" 3d "	—
24	" 4th "	—
25	" 5th "	—
26	" Trailers	30233
27	Total	184933
28	" on Drivers	121867
	CYLINDERS	
	Diam. and Stroke, H. P	20.5 x 26
	" " " L. P	—
	CLEARANCE IN PER CENT. OF PISTON DISPLACEMENT	
40	H. P. Right, Head End	16.5
41	" " Crank "	16.5
42	" Left, Head "	16.1
43	" " Crank "	15.9
44	L. P. Right, Head "	—
45	" " Crank "	—
46	" Left, Head "	—
47	" " Crank "	—
	RECEIVER, CUBIC FEET	
48	Volume Right Side	—
49	" Left "	—
	STEAM PORTS, INCHES	
50	H. P. Admission, Length	35.59
51	" " Width	2.03
58	L. P. " Length	—
59	" " Width	—
66	H. P. Exhaust, Length	NO PORT
67	" " Width	" "
70	L. P " Length	—
71	" " Width	—

No.	Item	Value
	PISTON RODS, DIAMETER INCHES	
74	High Pressure	3.474
75	Low "	—
	TAIL RODS, DIAMETER, INCHES	
78	High Pressure	—
80	Low "	—
	VALVES	
82	Type	PISTON
83	Design	AMERICAN BALANCE VALVE CO
84	Per Cent. Balanced	100
85	Type of Valve Motion	WALSCHAERTS
	GREATEST VALVE TRAVEL	
86	High Pressure, inches	6.83
88	Low " "	—
	STEAM LAP OF VALVE	
90	High Pressure, inches	1.36
94	Low " "	—
	EXHAUST LAP OF VALVE	
98	High Pressure, inches	NEGATIVE .31
102	Low " "	—
	BOILER	
113	Type	BELPAIRE, WIDE FIREBOX
114	Outside Diam. 1st Ring	67
	TUBES	
115	Number	315
116	Outside Diam., inches	2
	Pitch "	2.625
118	Length Between Tube Sheets, Inches	90.72
119	Total Fire Area, sq. ft.	5.26
124	Boiler Pressure, pounds	205
	SUPERHEATER	
125	Number of Tubes	—
126	Outside Diam. " inches	—
128	Length of " "	—
	FIREBOX, INSIDE, INCHES	
132	Length	114.24
133	Width	67.32
137	Air Inlets to Ashpan, sq. ft.	4.47
	GRATES	
144	Type	ROCKING, FINGER
145	Grate Area, sq. ft.	55.3
146	Area of Dead Grates SQ FT.	6.0

No.	Item	Value
	HEATING SURFACE, SQUARE FEET	
154	Of the Tubes, Water Side	2483.81
155	" " " Fire "	2173.42
156	" " Firebox, " "	162.61
157	" " Superh'r, " "	—
*158	Total, Based on " "	2336.03
159	" " " " " of Firebox and Water Side of Tubes	2646.52
	BOILER VOLUME WITH WATER SURFACE AT LEVEL OF 2D GAGE COCK	
160	Water Space, cu. ft.	330.4
161	Steam " " "	118.5
	EXHAUST NOZZLE	
162	Double or Single	SINGLE
163	Size, inches DIAM.	5.75
167	Area, sq. inches	25.97
	REVERSE LEVER	
168	H. P. Notches Forward of Center	15
169	L. P. Notches Forward of Center	—
	RATIOS	
171	Heating Surface (158) to Grate Area (145)	42.24
172	Fire Area Thru Tubes (119) to Grate Area (145)	10
173	Firebox Heating Surface (156) to Grate Area (145)	2.94
174	Tube Heating Surface (155) to Fire Box Heating Surface (156)	13.37

*USED IN CALCULATIONS

TABLE 3.— Simple Locomotive No. 3162.

M. P. 804 A—Sixth Sheet
8 x 10½

7 6 1907

PENNSYLVANIA RAILROAD COMPANY

Philadelphia, Baltimore & Washington Railroad Company
Northern Central Railway Company
West Jersey & Seashore Railroad Company
TEST DEPARTMENT

AVERAGE RESULTS OF LOCOMOTIVE TESTS

LOCOMOTIVE:
TYPE 4-4-2
CLASS E2A
NUMBER 5266

FUEL. SCALP LEVEL COAL

SUBJECT: LOCOMOTIVE TESTS WITH SCALP LEVEL COAL — ALTOONA, PA., 3-14-07

Test Number	RUNNING CONDITIONS: Test Designation	Duration of Test, Hours	Miles per Hour	Throttle Opening, Full or Partial	Actual Cut-off Per Cent., H. P. Cylinders		BOILER PERFORMANCE: Pressure in Boiler, Lbs. per Sq. Inch	Draft in Smoke Box, Inches of Water	Draft in Ash Pan, Inches of Water	Calorific Value of Dry Fuel, B.T.U. per Lb.	Cinders Collected in Smoke Box, Pounds per Hour
	R. P. M. Cut-off Throttle	198	199	203	268 to 271		217	222	226	248	238
901	80-15-F	3.00	19.10	FULL	15.7		201.3	2.0	.2	15264	52
902	80-20-F	3.00	19.10	"	17.9		200.1	2.1	1	15077	46
904	80-25-F	3.00	19.09	"	23.7		198.5	3.3	.7	15167	82
906	80-30-F	3.00	19.01	"	29.7		202.6	3.4	3	15020	66
908	120-20-F	3.00	28.65	"	18.8		201.0	3.9	7	15167	101
910	120-25-F	3.00	28.65	"	24.9		200.5	5.1	1.0	15167	236
912	120-30-F	2.50	28.65	"	31.7		202.7	4.9	.3	15057	110
913	160-15-F	3.00	38.20	"	16.7		198.0	3.1	2	15264	98
914	160-20-F	3.00	38.20	"	20.2		202.9	3.7	2	15264	194

Test Number	BOILER PERFORMANCE: Dry Fuel Fired per Hour, Pounds	Dry Fuel per Hour, Pounds per Sq. Ft. of Grate	Water Delivered to Boiler, Pounds per Hour	Equivalent Evaporation from and at 212° F., Pounds: Per Hour	Equivalent Evaporation: Per Hour per Sq. Ft. of Fire Heating Sur.	Equivalent Evaporation: Per Pound of Dry Fuel	Boiler Horse Power (34½ U. of E.)	Efficiency of Boiler, Based on Fuel		ENGINE PERFORMANCE: Pressure in Branch Pipe, Pounds per Sq. In.	Superheat in Branch Pipe, Degrees F.
	338	339	340	344	346	347	349	350		220	230
901	1868	30.00	14673	17806	7.68	10.69	516.0	67.68		198.3	0
902	1934	34.85	16075	19546	8.43	10.11	566.6	64.76		197.3	—
904	2177	39.23	18812	22466	9.69	10.32	651.1	65.71		192.8	4.09
906	2932	52.83	22536	27519	11.87	9.39	797.7	60.38		199.8	0
908	2488	44.24	20135	24434	10.54	9.98	708.2	63.36		197.7	4.20
910	3333	60.04	23334	28330	12.21	8.50	821.2	54.13		197.5	12.08
912	3988	71.86	27711	33792	14.68	8.47	979.4	54.32		197.8	12.43
913	2729	49.17	20759	25259	10.89	9.26	732.1	58.59		195.0	9.60
914	2998	54.01	22040	26851	11.58	8.96	778.3	56.68		198.2	11.72

Test Number	ENGINE PERFORMANCE: Dry Steam to Engines, Pounds per Hour	Indicated Horse Power	Dry Fuel per Indicated Horse Power Hour, Pounds	Dry Steam per Indicated Horse Power Hour, Pounds		LOCOMOTIVE PERFORMANCE: Drawbar Pull, Pounds	Dynamometer or Drawbar Horse Power	Dry Fuel per Dynamom. Horse Power Hour, Pounds	Dry Steam per Dynamom. Horse Power Hour, Pounds	Machine Efficiency of Locomotive, Per Cent.	Thermal Efficiency of Locomotive, per Cent., (Based on Fuel)
	214	379	380	381		268	383	384	386	398	399
901	14082	419.8	3.97	33.54		6427	327.3	5.09	43.02	77.96	3.28
902	15397	477.2	4.05	32.27		7653	389.8	4.96	39.50	81.68	3.40
904	17945	585.6	3.72	30.68		9810	499.6	4.36	35.92	85.35	3.85
906	21790	727.9	4.03	29.94		12475	632.3	4.64	34.46	86.87	3.65
908	19552	687.6	3.57	28.81		7280	556.2	4.42	35.16	80.89	3.79
910	22719	851.1	3.92	26.70		9438	721.1	4.62	31.51	84.71	3.63
912	26458	1015.4	3.93	26.63		11765	900.8	4.43	29.39	88.71	3.82
913	20034	748.8	3.64	26.75		5578	566.2	4.80	35.26	75.86	3.47
914	20948	826.8	3.63	25.34		6538	665.9	4.80	31.46	80.54	3.71

TABLE 4.— Test of Simple Locomotive No. 5266.

M. P. 804 A—Sixth Sheet
8 x 10½

Pennsylvania Railroad Company

Philadelphia, Baltimore & Washington Railroad Company
Northern Central Railway Company
West Jersey & Seashore Railroad Company

TEST DEPARTMENT

Average Results of Locomotive Tests

LOCOMOTIVE:
TYPE 4-4-2
CLASS E2A
NUMBER 5266

FUEL: SCALP LEVEL COAL

SUBJECT: LOCOMOTIVE TESTS WITH SCALP LEVEL COAL — ALTOONA, PA., 3-14-07

Test Number	Running Conditions: Test Designation	Duration of Test, Hours	Miles per Hour	Throttle Opening, Full or Partial	Actual Cut-off Per Cent., H.P. Cylinders	Boiler Performance: Pressure in Boiler, Lbs. per Sq. Inch	Draft in Smoke Box, Inches of Water	Draft in Ash Pan, Inches of Water	Calorific Value of Dry Fuel, B.T.U. per Lb.	Cinders Collected in Smoke Box, Pounds per Hour
	R. P. M. Cut-off Throttle	196	199	203	268 to 271	217	222	225	248	238
916	160-25-F	2.50	38.20	FULL	24.9	200.0	5.2	.3	15264	302
917	160-27-F	3.00	38.20	"	27.7	188.4	7.7	.3	15167	492
918	160-30-F	1.00	38.20	"	31.8	186.1	6.9	1.3	15167	987
920	200-20-F	2.50	47.75	"	19.5	202.0	5.0	.2	15264	264
922	200-25-F	1.20	47.75	"	25.5	202.1	6.0	.3	15057	316
923	240-15-F	1.50	57.30	"	19.0	196.4	5.6	.2	15020	508
924	240-20-F	1.00	57.30	"	21.6	197.5	5.4	.3	15020	514
927	280-15-F	1.00	66.85	"	19.9	194.4	5.6	2	15020	584
929	320-15-F	—	76.08	"	21.4	—	—	—	—	—

Test Number	Boiler Performance: Dry Fuel Fired per Hour, Pounds	Dry Fuel per Hour, Pounds per Sq. Ft. of Grate	Water Delivered to Boiler, Pounds per Hour	Equivalent Evaporation from and at 212° F., Pounds: Per Hour	Per Hour per Sq. Ft. of Fire Heating Sur.	Per Pound of Dry Fuel	Boiler Horse Power (34½ lb. of E.)	Efficiency of Boiler, Based on Fuel	Engine Performance: Pressure in Branch Pipe, Pounds per Sq. In.	Superheat in Branch Pipe, Degrees F.
	238	239	240	244	246	247	249	260	228	230
916	4221	76.05	26436	32246	13.90	7.64	934.7	48.34	195.0	18.57
917	4802	86.53	28670	34793	15.00	7.25	1008.5	46.17	185.6	35.51
918	5581	100.80	30721	37170	16.03	6.66	1077.4	42.41	181.6	30.36
920	3694	66.56	26113	31841	13.73	8.62	922.9	54.52	197.4	17.16
922	4983	89.78	30300	36981	15.94	7.42	1071.9	47.59	197.1	22.23
923	5080	91.93	27365	33383	14.39	6.57	967.6	42.28	194.2	15.93
924	6101	109.92	28670	35014	15.10	5.74	1014.9	36.91	195.1	16.29
927	5012	90.31	28800	35240	15.19	7.03	1021.4	45.20	191.7	14.73
929	—	—	—	—	—	—	—	—	—	—

Test Number	Engine Performance: Dry Steam to Engines, Pounds per Hour	Indicated Horse Power	Dry Fuel per Indicated Horse Power Hour, Pounds	Dry Steam per Indicated Horse Power Hour, Pounds	Locomotive Performance: Drawbar Pull, Pounds	Dynamometer or Drawbar Horse Power	Dry Fuel per Dynamom. Horse Power Hour, Pounds	Dry Steam per Dynamom. Horse Power Hour, Pounds	Machine Efficiency of Locomotive, Per Cent.	Thermal Efficiency of Locomotive, per Cent., Standard Fuel
	214	279	280	281	286	283	284	285	286	289
916	25536	1011.6	4.17	25.23	8155	830.7	5.08	30.73	82.11	3.28
917	27962	1055.0	4.55	26.50	8757	892.1	5.38	31.34	84.56	3.19
918	30060	1133.4	4.92	26.46	9571	975.0	5.72	30.83	86.02	2.93
920	25259	1018.6	3.63	24.83	6199	789.4	4.68	32.04	77.49	3.56
922	29176	1223.7	4.07	23.84	7701	980.6	5.08	29.75	80.13	3.33
923	26698	1088.4	4.66	24.60	4940	880.7	5.77	30.31	81.14	2.94
924	28375	1164.5	5.24	24.37	5908	902.5	6.76	31.43	77.53	2.51
927	28057	1178.4	4.25	23.81	4752	847.2	5.92	33.12	71.89	2.86
929	—	1281.3	—	—	—	—	—	—	—	—

TABLE 5.— Tests of Simple Locomotive No. 5266.

M. P. 804 A—Sixth Sheet
7 6 1907

PENNSYLVANIA RAILROAD COMPANY
Philadelphia, Baltimore & Washington Railroad Company
Northern Central Railway Company
West Jersey & Seashore Railroad Company
TEST DEPARTMENT

AVERAGE RESULTS OF LOCOMOTIVE TESTS

LOCOMOTIVE: TYPE 4-4-2 CLASS E2D NUMBER 3162

FUEL: GAS COAL

SUBJECT: LOCOMOTIVE TESTS WITH GAS COAL — ALTOONA, PA., 1-15-08

TEST NUMBER	RUNNING CONDITIONS: Test Designation	Duration of Test, Hours	Miles per Hour	Throttle Opening, Full or Partial	Actual Cut-off Per Cent., H. P. Cylinders		BOILER PERFORMANCE: Pressure in Boiler, Lbs. per Sq. Inch	Draft in Smoke Box, Inches of Water	Draft in Ash Pan, Inches of Water	Calorific Value of Dry Fuel, B.T.U. per Lb.	Cinders Collected in Smoke Box, Pounds per Hour
	R. P. M. Cut-off Throttle	196	199	203	268 to 271		217	222	226	248	236
1131	80-15-F	.75	18.61	FULL	14.3		205.4				
1116	80-20-F	3.00	18.61	"	26.5		203.2				
1125	80-30-F	.50	18.56	"	28.3		204.9				
1130	120-15-F	.75	27.91	"	14.5		203.5				
1128	120-20-F	.75	27.87	"	22.8		204.5				
1122	120-30-F	1.83	27.91	"	30.2		203.8				
1129	160-15-F	.50	37.24	"	14.8		203.6				
1127	160-20-F	.50	37.19	"	22.3		204.3				
1124	160-30-F	.50	37.24	"	29.5		204.4				
1132	160-30-F	.50	37.22	"	31.7		201.9				

TEST NUMBER	BOILER PERFORMANCE: Dry Fuel Fired per Hour, Pounds	Dry Fuel per Hour, Pounds per Sq. Ft. of Grate	Water Delivered to Boiler, Pounds per Hour	Equivalent Evaporation from and at 212° F., Pounds: Per Hour	Per Hour per Sq. Ft. of Fire Heating Sur.	Per Pound of Dry Fuel	Boiler Horse Power (34½ U. of E.)	Efficiency of Boiler, Based on Fuel		ENGINE PERFORMANCE: Pressure in Branch Pipe, Pounds per Sq. In.	Superheat in Branch Pipe, Degrees F.
	338	339	340	344	346	347	349	350		220	230
1131	—										
1116	1729										
1125	—										
1130	—										
1128	—										
1122	3013										
1129	—										
1127	—										
1124	—										
1132	—										

TEST NUMBER	ENGINE PERFORMANCE: Dry Steam to Engines, Pounds per Hour	Indicated Horse Power	Dry Fuel per Indicated Horse Power Hour, Pounds	Dry Steam per Indicated Horse Power Hour, Pounds		LOCOMOTIVE PERFORMANCE: Drawbar Pull, Pounds	Dynamometer or Drawbar Horse Power	Dry Fuel per Dynamom. Horse Power Hour, Pounds	Dry Steam per Dynamom. Horse Power Hour, Pounds	Machine Efficiency of Locomotive, Per Cent.	Thermal Efficiency of Locomotive, per Cent. (Based on Fuel)
	214	379	380	381		286	383	384	385	398	399
1131	11604	401.8	—	28.88		6912	343.0	—	33.83	85.36	—
1116	14814	527.8	3.28	28.07		9160	454.8	3.80	32.60	86.11	4.72
1125	17357	653.4	—	26.56		11427	565.6	—	30.99	86.56	—
1130	15788	617.3	—	25.57		6732	501.1	—	31.50	81.18	—
1128	20034	796.2	—	25.60		8992	668.2	—	29.98	83.92	—
1122	25555	977.7	3.08	26.14		11697	870.7	3.44	29.35	89.06	5.18
1129	18904	775.7	—	24.37		5909	586.8	—	32.22	75.65	—
1127	23512	993.6	—	23.64		8207	814.1	—	28.88	81.93	—
1124	29233	1199.5	—	24.37		10515	1044.2	—	28.00	87.05	—
1132	28520	1196.8	—	23.87		10114	1003.8	—	28.46	83.87	—

TABLE 6.—Tests of Simple Locomotive No. 3162.

M. P. 804 A—Sixth Sheet
8 x 10½

PENNSYLVANIA RAILROAD COMPANY

Philadelphia, Baltimore & Washington Railroad Company
Northern Central Railway Company
West Jersey & Seashore Rail and Company

TEST DEPARTMENT

AVERAGE RESULTS OF LOCOMOTIVE TESTS

LOCOMOTIVE:
TYPE 4-4-2
CLASS E26
NUMBER 3162

FUEL: GAS COAL

SUBJECT: LOCOMOTIVE TESTS WITH GAS COAL

ALTOONA, PA., 1-15-08

TEST NUMBER	RUNNING CONDITIONS: Test Designation	Duration of Test, Hours	Miles per Hour	Throttle Opening, Full or Partial	Actual Cut-off Per Cent., H. P. Cylinders		BOILER PERFORMANCE: Pressure in Boiler, Lbs. per Sq. Inch	Draft in Smoke Box, Inches of Water	Draft in Ash Pan, Inches of Water	Calorific Value of Dry Fuel, B.T.U. per Lb.	Cinders Collected in Smoke Box, Pounds per Hour
	R. P. M. Cut-off Throttle	196	199	203	268 to 271		217	222	226	248	238
1133	160-30-F	.50	37.22	FULL	32.0		202.4				
1120	160-32-F	.50	37.19	"	36.8		204.3				
1126	200-20-F	.50	46.45	"	24.7		203.3				
1117	200-30-F	50	46.52	"	33.4		203.1				
1123	200-30-F	1.00	46.29	"	32.3		186.7				
1118	200-32-F	—	46.48	"	37.8		198.5				
1121	200-32-F	—	46.52	"	36.2		191.0				
1119	240-15-F	—	55.83	"	20.4		203.8				

TEST NUMBER	BOILER PERFORMANCE: Dry Fuel Fired per Hour, Pounds	Dry Fuel per Hour, Pounds per Sq. Ft. of Grate	Water Delivered to Boiler, Pounds per Hour	Equivalent Evaporation from and at 212° F., Pounds: Per Hour	Equivalent Evaporation: Per Hour per Sq. Ft. of Fire Heating Sur.	Equivalent Evaporation: Per Pound of Dry Fuel	Boiler Horse Power (34½ U. of E.)	Efficiency of Boiler, Based on Fuel		ENGINE PERFORMANCE: Pressure in Branch Pipe, Pounds per Sq. In.	Superheat in Branch Pipe, Degrees F.
	338	339	340	344	346	347	349	350		220	230
1133										—	—
1120										200.8	0
1126										—	—
1117										198.8	0
1123										—	—
1118										—	—
1121										—	—
1119										—	—

TEST NUMBER	ENGINE PERFORMANCE: Dry Steam to Engines, Pounds per Hour	Indicated Horse Power	Dry Fuel per Indicated Horse Power Hour, Pounds	Dry Steam per Indicated Horse Power Hour, Pounds		LOCOMOTIVE PERFORMANCE: Drawbar Pull, Pounds	Dynamometer or Drawbar Horse Power	Dry Fuel per Dynamom. Horse Power Hour, Pounds	Dry Steam per Dynamom. Horse Power Hour, Pounds	Machine Efficiency of Locomotive, Per Cent.	Thermal Efficiency of Locomotive, per Cent., (Based on Fuel)	
	214	379	380	381		265	383	384	386	398	399	
1133	29443	1194.1	—	24.66		10071	999.5	—	29.48	83.70	—	
1120	33103	1323.4	—	25.01		11674	.157.9	—	28.89	87.49	—	
1126	28255	1191.1	—	23.72		7489	9277	—	30.46	77.89	—	
1117	34777	1413.9	—	24.60		8700	1079.3	—	32.22	76.33	—	
1123	31957	1300.7	4.31	24.57		8460	1044.3	5.37	30.60	80.29	3.34	
1118	—	1497.4	—	—		—	—	—	—	—	—	
1121	—	1464.9	—	—		—	—	—	—	—	—	
1119	—	1052.0	—	—		—	—	—	—	—	—	

TABLE 7.—Test of Simple Locomotive No. 3162—Continued.

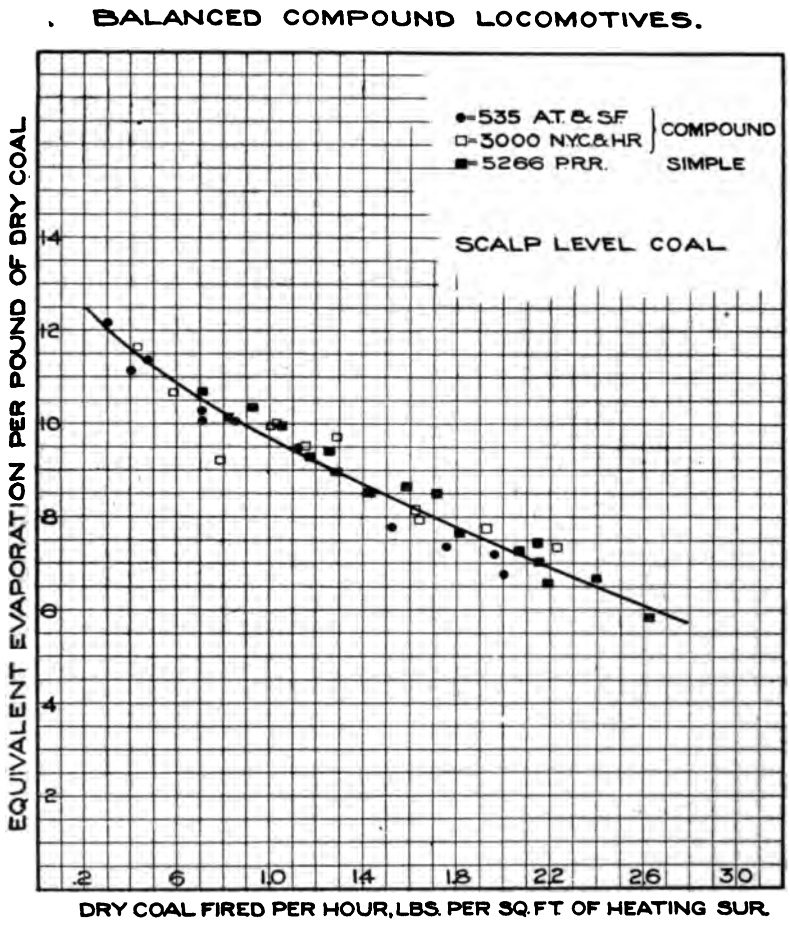


FIG. 1.— Evaporation per Pound of Coal.

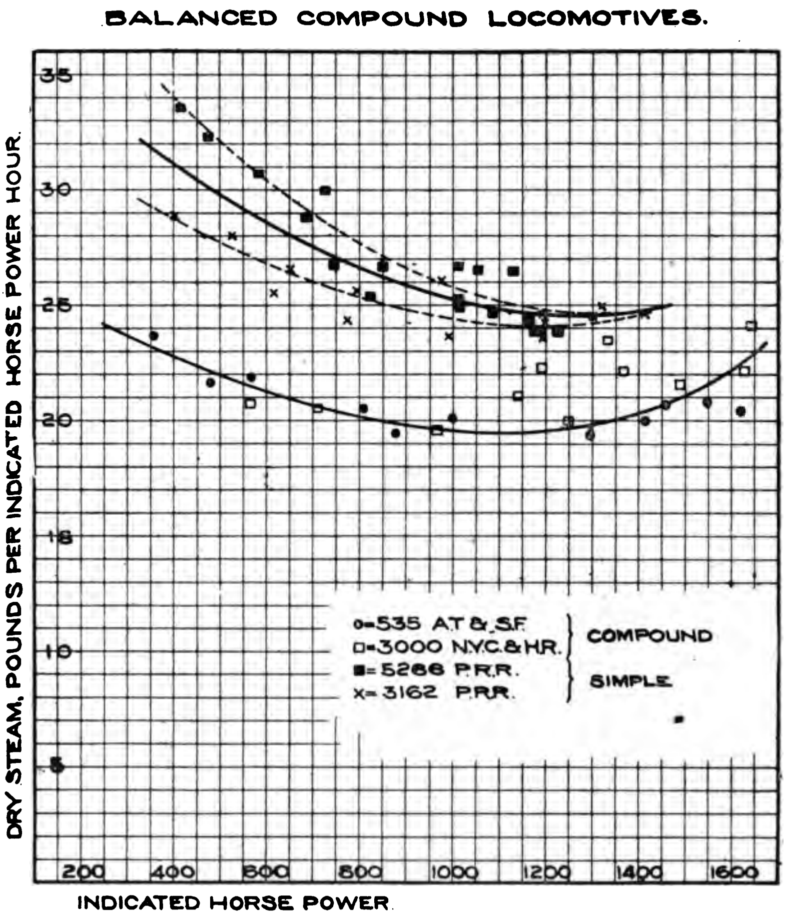


FIG. 2.— Steam Consumption, Compound and Simple Locomotives.

BALANCED COMPOUND LOCOMOTIVES.

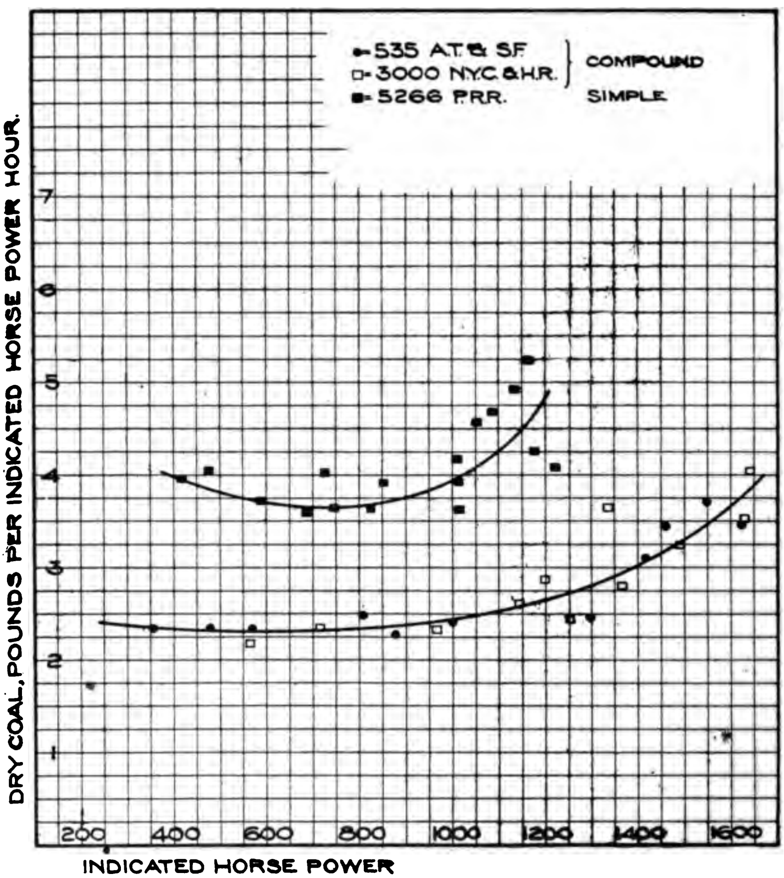


FIG. 3.— Coal Consumption, Compound and Simple Locomotives.

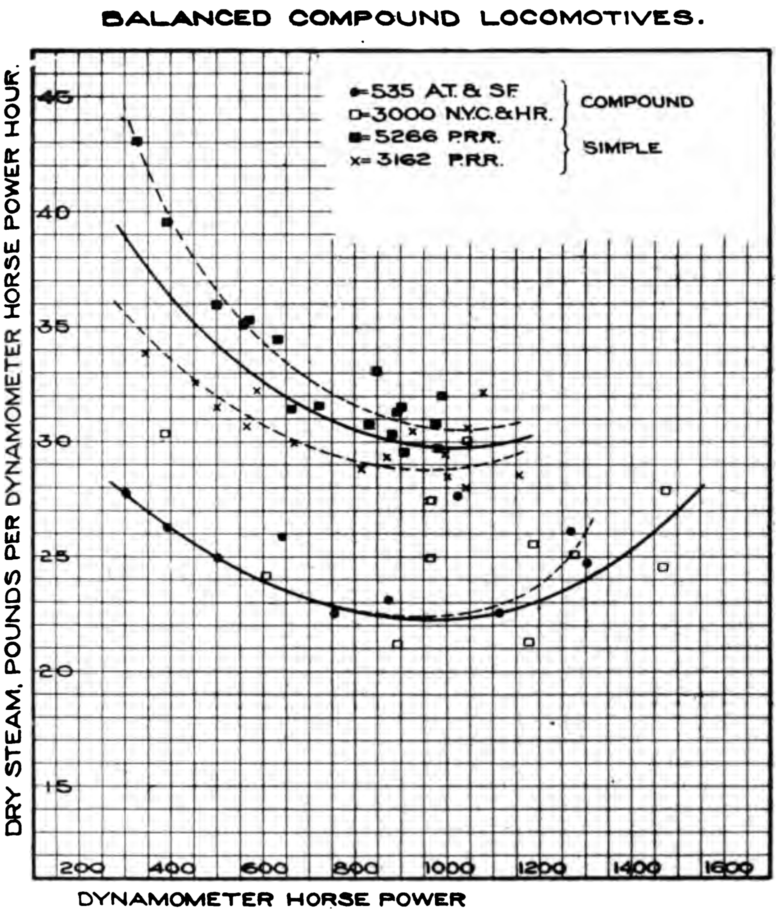


FIG. 4.— Steam Consumption, Compound and Simple Locomotives.

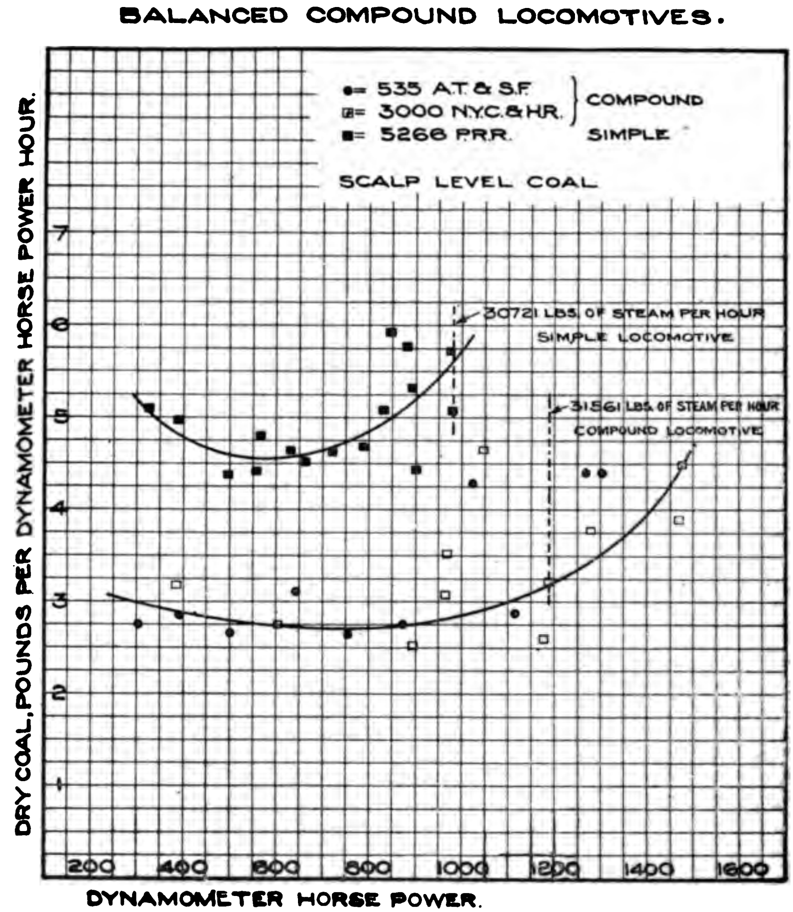


FIG. 5.— Coal Consumption, Compound and Simple Locomotives.

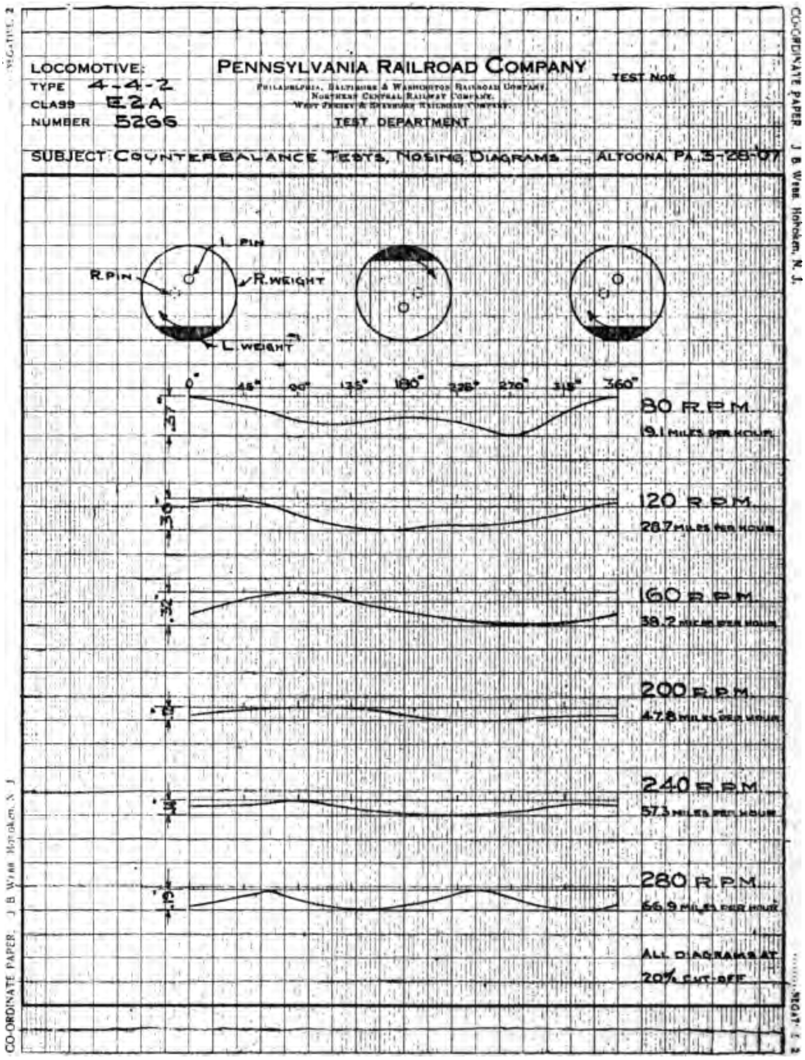


FIG. 6.— Counterbalance Tests, Simple Locomotive No. 5266.

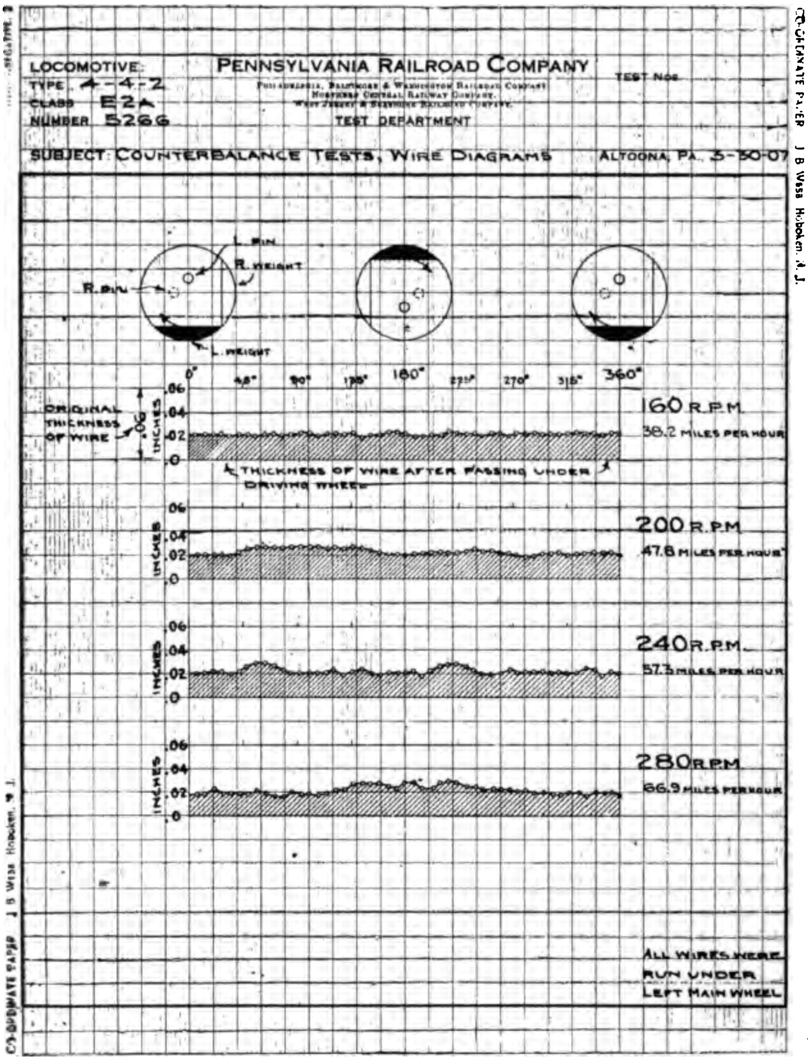


FIG. 7.— Counterbalance Tests, Simple Locomotive No. 5266.

COMPARISON OF RESULTS.

From Fig. 2 it will be seen that the steam per indicated horse-power of the compound locomotives tested is more uniform throughout the range of horse-power than the simple engine. The greatest difference is at low horse-powers. This saving decreases as the horse-power increases, but if the boiler of the simple locomotive made it possible to continue the test to the maximum horse-power attainable with the compound, there might be more difference.

Inasmuch as the data of these tests for both compound and simple locomotives was taken at various percentages of cut-off at the different speeds, the statement above as to relative water rate and horse-power may be considered as obtaining under general running conditions.

From an inspection of Figs. 3 and 5, where the performance based on indicated and dynamometer horse-power is shown, as referred to coal, the saving of the compound throughout its range of action is indicated, and it is to be noticed that at the low indicated horse-powers (Fig. 3), the saving with the compound is greater than at horse-powers of about 800, and from Fig. 5 the least difference is shown at about 500 horse-power; horse-powers beyond these figures showing increased economy with the compound locomotive.

The advantage of compounding in adding to the capacity of the locomotive at speeds above those which may be called starting speeds, is clearly indicated. A boiler of the same heating surface in a locomotive equipped with compound cylinders, has a decided advantage over one equipped with simple cylinders, because the consumption of steam is less with the compound cylinders for a given horse-power developed.

It is, therefore, clear that a balanced compound locomotive, while more economical in steam and fuel than a simple locomotive, has also an increased advantage over the simple locomotive in capacity.

When developing 800 dynamometer horse-power, the compound locomotive shows about 2.70 pounds of fuel per horse-power hour at the drawbar, while the simple locomotive shows about 4.85 pounds. This apparent saving in the compound over the simple locomotive is approximately 44 per cent based on fuel, and it varies somewhat with greater and less horse-powers. It should be noted, however, that this saving is not all due to the difference between the simple and compound cylinders.

Figure 1 shows that the equivalent evaporation based on dry coal fired per hour per square foot of heating surface, is apparently the same for all of the three boilers under consideration. That is to say, at any given rate of burning coal per square foot of heating surface, the efficiency of all the boilers is approximately the same. It is probably more satisfactory to estimate the out-put of the boilers based on coal burned per square foot of grate, and if this basis is chosen, the relation of the boilers is very much as shown in Figure 1, although there is an indication that the boilers with the larger heating surface are more economical than the boiler with the smaller heating surface. The point to which attention is

especially directed is that the efficiency of the boiler and grate decreases as the rate at which the coal is burned increases. Therefore, when the demand on the boiler is less for the same horse-power developed in the cylinders, then a part of the saving shown as a total is to be attributed to the better efficiency of the boiler and grate at lower rates of coal burned per hour. In these tests the same coal was used, so that the character of the fuel, which is an important element, can be eliminated.

In tests 605 and 606 the efficiencies of the Atchison, Topeka & Santa Fe locomotive No. 535 were 66.16 per cent and 66.99 per cent, the equivalent evaporation per hour being 21,128 pounds and 24,885 pounds, or an average of 23,016 pounds per hour. In test 904 the efficiency of the boiler of locomotive No. 5266 was 65.71 per cent, the equivalent evaporation being 22,466 pounds per hour. This shows that if the boiler of locomotive No. 5266 had been equipped with the cylinders of locomotive No. 535, the efficiency of the former as a whole would have been practically the same as the efficiency of locomotive No. 535 as tested. This makes it plain that part of the economy of the compound is due to the greater efficiency of the boiler with compound cylinders, due to less total water being required for a given dynamometer horse-power. The saving in fuel on this account is about 18 per cent for the locomotive with compound cylinders as compared with the simple locomotive when both are developing approximately 800 dynamometer horse-power.

This explanation is simply analytical, in order that the factor of the boiler and grate shall not be overlooked. The fact still remains, however, that with two boilers of exactly the same design, one equipped with simple cylinders and the other with compound cylinders, and performing the same work, that economy will be realized, and it is due not only to the better cylinder performance with the compound locomotive, but to the fact that the boiler and grate are not called upon for as large an output where compound cylinders are used as where the simple cylinders are used, and considering the amount of work to be performed the same in both cases.

BALANCING.

In the Pennsylvania Railroad report of the St. Louis tests there are shown diagrams which illustrate the perfection of balance of the locomotives, both vertically and horizontally, and on Figs. 6 and 7 similar results are shown for locomotive No. 5266.

It was made clear from the tests of the four-cylinder compounds, that great care is necessary in the design of the weight and location of the counterbalance in this type of locomotive, in order to realize all of the advantages that are possible from this type.

Since the St. Louis tests, however, the method of counterbalancing balanced compounds is much better understood, and it is doubtful if a simple locomotive can be as satisfactorily counterbalanced. From the tests recently made on the simple locomotive, Figs. 6 and 7, it may be

possible to much more effectually balance a simple locomotive than has generally been thought possible.

Locomotive No. 5266 was not observed to leave the rail at speeds as high as 320 revolutions per minute, or 76 miles per hour, and its critical speed, or the speed where severe fore and aft vibration began, was as high as 200 revolutions per minute, or 48 miles per hour.

The method used in balancing locomotive No. 5266 was to place in the driving wheels weights equivalent to all of the revolving and two-thirds of the reciprocating weights.

By actual weighing of these balance weights in the wheels, the right main wheel was found to have 17 pounds too much; the left main wheel 20 pounds too much; the right and left front wheels were found to have, each, 2.6 pounds too much, all these weights being at the crank pin radius.

SERVICE DATA.

In regard to the cost of maintenance and the cost of fuel, as actually developed in road trials, or in regular road service, your committee has been unable to secure sufficient data to present with any assurance of covering the ground in a satisfactory way.

One of the difficulties is probably due to the fact that railroads are not keeping the cost of fuel and repairs in a way which can be compared directly.

Furthermore, the balanced compound locomotives have been in service for but a few years, and probably not long enough to determine satisfactorily the cost of maintenance, as compared with the simple locomotives.

In an effort to secure this information, however, your committee sent statements covering the information desired to the heads of the mechanical departments of fifteen roads. These were selected as they had in service both compound and simple locomotives of the same types. Eight replies were received up to the time of preparing this report, of which five gave information more or less complete. The items asked for are given below, and these were desired for each of several periods, covering the service of the locomotive between general repairs.

The general heading was:

1. Locomotive No. ....
   Class ....
   Compound or simple..
   Date built ....
   Name of builder..
   Service ....
   Weight of train..
   Number of stops..
   Average speed between terminals........................
   Runs made between..................and..............
   Distance between terminals ....

This statement can be compared with the one covering locomotive No.......

The details with comments on the information collected are given below, more for their value as a suggested analysis than for the actual information contained. Comment is made where the information suggests it.

2. Total mileage.
3. Total car mileage.
4. Total ton mileage.
5. Average cars per train.
6. Total coal used.
7. Coal per car mile, pounds.
8. Coal per gross ton mile, pounds.
9. Cost of coal per 1,000 car miles.
10. Cost of coal per 1,000 gross ton miles.
11. Total cost of running repairs (a) boiler; (b) machinery.
12. Total cost of general repairs (a) boiler; (b) machinery.

The items Nos. 11 to 15, inclusive, were intended to separate boiler and machinery repairs, but the information sent did not divide it under these sub-headings. The only item generally given is No. 15.

13. Cost per 100 miles running repairs (a) boiler; (b) machinery.
14. Cost per 100 miles general repairs (a) boiler; (b) machinery.

The cost is separated under these two items by one road for two 4-4-2 compounds, but no comparison is given for simple locomotives. Another gives these for one compound, and the average for 47 simple locomotives.

15. Cost per 100 miles for all repairs (a) boiler; (b) machinery.

This is given in all cases but one. It varies from $1.44 to $10.10 for simple locomotives, and from $2.60 to $13.40 for compounds. On one road the cost given for one simple locomotive is 57 per cent greater than the cost of the other, these being the only two included. For two compounds on the same road, one costs 70 per cent more for repairs than the other. Even averaging these would be unfair as forming a basis for conclusions.

Another road shows two simple locomotives with superheater compared with two compounds without, all four being of about the same weight and capacity. The cost per 100 miles averaged is $1.49 for the simple and $2.60 for the compounds. These figures must include only a portion of the costs and can not be considered as comparative.

16. Grease or oil lubrication of machinery, excluding cylinders.
17. Cost for all lubricants, including cylinders.
18. Cost per 100 miles for all lubricants.
19. Total cost of coal, lubricants and repairs.
20. Cost for coal, lubricants and repairs, per 1,000 car miles.
21. Cost for coal, lubricants and repairs, per 1,000 ton miles.

No data on these items were received, except from one road, giving

the cost under item 18, but as only one compound is included, it is not safe to form any conclusion.

22. Number of end frames broken.

23. Number of main frames broken.

24. Number of cracked or broken cylinders.

The data is so extremely limited that it is considered of no value.

25. Mileage between resetting flues.

The information is limited, and as the basis for life of flues varies on different roads, this data is of little value.

26. Life of fire box, years.

No comparisons are given.

27. Mileage between turning of tires.

No comparisons of value.

28. Average days out of service per year, on account of repairs.

No information given that throws any light on the subject.

The following note appeared at the end of the statement sent to the railroads:

29. NOTE.— Ton miles are to be considered gross tons of 2,000 pounds, or, in other words, the locomotive to be given credit for hauling the tons of empty cars as well as tons of loaded cars, in freight service.

If grease lubricant is used in driving boxes and rods, or driving boxes only, the material used for machinery should be stated as "grease." If oil is used for driving boxes and grease for rods, the lubricant used should be stated as "oil."

It is desired to have the figures for gross ton-miles in freight service, if possible, but in any case, it is assumed that the figures including car-miles, can be given. In case of the latter, two empty cars are to be considered as one loaded car. In passenger service the tons weight of train should be given without allowance for weight of passengers.

Comparisons between simple and compound locomotives are to be given for the same character of service, and over the same portions of road and between the same points, traffic in both directions to be taken.

CONCLUSIONS.

It has been shown that in the foregoing that with the use of balanced compound locomotives a very considerable saving in fuel and water for the same work done, may be accomplished. It is equally clear from the discussion that the capacity of the locomotive with compound cylinders is increased.

The figures which have been given for fuel and water are, it is true, obtained on the locomotive testing plant where the conditions of running are uniform, and in road service the relative economy will undoubtedly be somewhat changed.

The testing plant does not give any figures on the cost of maintenance, and your committee, being unable to secure any data on this subject, is unable to give conclusions in regard to the ultimate economy.

Your committee, however, is impressed with the possible saving in regular service of balanced compound locomotives, and this would undoubtedly be realized with other types of compounds, but as the results in actual service are those which must finally be depended upon for ultimate economy, your committee would recommend to the members of the Association a careful record of performance, in order to determine how far the economy in fuel and water can be realized, when all factors are considered.

The analysis already given and prepared for the purpose of determining the question of costs of maintenance, as well as the comparative cost of fuel, apparently covers the points involved sufficiently, but as already stated, your committee could not secure this data covering a sufficient number of compound and simple locomotives to draw definite conclusions.

Some action of the Association, which will secure the coöperation of railroads in preparing information on this basis for the next convention, might produce valuable comparisons. It is necessary to have these records of performance covering the period from the time the locomotive was built and placed in service up to and including the most recent data concerning its performance.

This would involve probably considerable work in going over old records, but if some satisfactory conclusions could be reached in regard to this matter on the basis of ultimate economy, a decided step forward would be gained in railroad operation.

Respectfully submitted,

E. D. NELSON, Chairman,
JOHN HOWARD,
S. M. VAUCLAIN,
A. LOVELL,
J. F. GRAHAM,
Committee.

ALTOONA, PA., May 28, 1908.

THE PRESIDENT: This matter is now before you for discussion.

MR. NELSON: I think we all agree that the most satisfactory basis on which to measure the fuel consumption is the actual work done or the drawbar horse-power. Now, it has been stated in the report, as taken from the plot, on page 15, that with the compounds this amounted to about forty-four per cent at eight hundred horse-power, but there is one variable that we find on a locomotive-testing plant, and that is the friction of the locomotive, and probably it would be interesting to note for a

minute the economy in water and coal based on indicated horse-power. That is to say, on page 12 the steam per indicated horse-power shows at 800 horse-power about twenty-four per cent less for the compound, and on page 13, the coal consumption per indicated horse-power shows in favor of the compound about thirty-six per cent. In some ways it is more satisfactory to compare coal consumption on indicated horse-power than it is on dynamometer horse-power.

MR. HENDERSON: I do not know whether the chairman of this committee can answer the question or not, but it occurs to me that some years ago it was found necessary in running large compounds down hill to use a certain amount of steam on account of the back pressure, and I would like to know whether the committee has any information regarding these balanced compounds, whether they are in the same category, that is, whether it is necessary to use steam running down hill?

MR. NELSON: The committee has had no information on the point raised by Mr. Henderson.

THE PRESIDENT: We would be pleased to hear from Mr. Vauclain on this subject.

MR. VAUCLAIN: Mr. President, the discussion of the report on Compound Locomotives carries one back several years to the old days when we had J. N. Barr with us; D. L. Barnes, J. N. Lauder, George Gibbs and some more, many of whom have gone from us never more to return. In those days, the discussion of a paper on Compound Locomotives brought master mechanics and superintendents of motive power from every point of the United States to hear what was going to be said, because it was certain there would be many positive opinions expressed; some for and some against the use of compound locomotives, and the advocates of the various types would be there to assure every master mechanic who might be present that the particular type of compound which he represented was *the* compound and was the one which ultimately would be the standard locomotive of the future. The report to-day on Compound Locomotives seems to be more *in memoriam* than anything else, but I am very glad that we have had the opportunity of

making a report such as this on Balanced Compound Locomotives. The credit for this report is due mainly to Mr. Nelson, of the Pennsylvania Road. Speaking for myself, I have done very little toward compiling it, feeling it was far better for me to keep quiet than to have any voice, that is to have a voice to any extent in the preparation of the data which might be presented to you. I was especially desirous, however, of having a little to say this morning in connection with this report. I think this report fully justifies the opinion of every advocate of compound locomotives who has appeared on this floor for the past fifteen years. I am quite sure that it fully justifies the use of all compound locomotives, of any type whatsoever, that may be in use at the present time, and it further justifies the adherence of those who are now using compound locomotives, and who stick to them tenaciously, and will not give them up for what we now think are going to be the locomotives of the future, namely, those locomotives using superheated steam.

If you will go over the report carefully, and consider merely the matter of coal and steam consumption, you will find a few very conclusive figures. The steam consumption per indicated horse-power, as mentioned by Mr. Nelson at about eight hundred horse-power, shows a percentage of saving of twenty-four per cent. It will also be noticed that the faster the compound engine is operated the lower this percentage of steam economy will be. That is what has been proven in actual service every day since we commenced to use compound locomotives, and has always been the claim of every reputable builder of compound engines. The percentage of saving per dynametric horse-power is also in accordance with the steam consumption per indicated horse-power, and at the mean power of 800 horse-power shows only 25.5 per cent. Referring to the matter of coal consumption you will find that we have percentages of economy per indicated horse-power ranging from 38 to as high as 54.10 per cent. These percentages of coal economy have been taken off a standard apparatus, where every appliance we know has been made use of to get a careful and accurate record, and these figures fully justify what was considered many times in these meetings, that those who came here and claimed a fuel economy of forty

or forty-five per cent for compound locomotives in actual service were not incorrect in their statements. These figures proved that that percentage was correct. In those times any one who came before the convention and talked about saving thirty to forty per cent of coal was looked upon with some amusement, and, I will say, considerable doubt as to the accuracy of his figures. If we go a little farther, to the coal per dynametric horse-power, we will see that the same figures are borne out practically here, namely, 39.6 up to 50.5 per cent, which was the range of a single-expansion engine. Unfortunately, in these tests, the single-expansion engine was not capable of being carried to the same high horse-power that was obtained from the compound locomotives. This is not entirely due to the fact that one engine had compound cylinders on and the other had not, but the Pennsylvania single-expansion locomotives were handicapped by not having as much heating surface as the boilers of the compound locomotives had. So far as the Santa Fe locomotive is concerned, they had about twenty per cent less, but there is a difference, under maximum conditions of fifty per cent in round figures, in these two engines, twenty per cent of which might fairly be attributed to the fact that the one engine did not possess so much heating surface.

When figures are presented to you, which show that a single-expansion locomotive has as its limit of horse-power about 1,000 and that compound locomotives of practically the same weight can be carried to 1,600 horse-power, it proves conclusively that not only have compound locomotives been economical from the time economy was claimed for them, but that boiler capacity must be considered, as it has been considered in the past, in relation to single-expansion locomotives.

These figures, gentlemen, explain why reports have been presented to you from time to time, which clearly showed that Atlantic type balanced compounds were capable of hauling the same trains that Pacific type single-expansion locomotives hauled, and making better time with them, or that they were capable of hauling much heavier trains than a single-expansion Pacific type locomotive could haul, and make the same schedule time. This was due merely to their having an increased amount of heating

surface in their boiler, plus the economy that could be shown by compounding cylinders, over single-expansion cylinders.

It gives me more comfort than any of you gentlemen here present can imagine to go over the figures in this report. I have read them over and over and have complimented Mr. Nelson on the effectiveness and thoroughness of his work, and upon the straightforward manner in which these figures have been presented at the convention, and while I believe there will not be so very many compound locomotives built in the future,— I think that balanced compound and Mallet compounds will still continue to be built,— but that the superheater locomotive will, perhaps, take the place of the majority of locomotives in railroad service.

THE PRESIDENT: We would like to hear from some of those gentlemen who come in direct contact with the balanced compound locomotive. Is Mr. MacBain, of the Michigan Central R. R., here?

MR. D. R. MACBAIN (Michigan Central R. R.): We have not had any experience with the balanced compound on the Michigan Central. Our experience has been confined entirely to the two-cylinder cross-compound freight engine.

MR. CLARK: We have twenty balanced compound locomotives, the first of which went into service about four years ago. Most of them have built up crank axles, and all of them had the outside cylinders connected by main rods to the rear driving axle. The results of service have been on the whole very satisfactory. We think that the locomotives take a little more time in the roundhouse than the simple engines, but we seem to have time to do this, and as a consequence the engines make good mileage, and make their mileage with very few road failures.

I was somewhat surprised that the committee did not make more of a certain feature of the balanced compound locomotive, which I think is an important thing with that type of locomotive, and that is the effect on the track. We found that it was possible to balance these locomotives in such way that the disturbance to the track was very much less than with a simple locomotive of the same type properly counterbalanced and of less total weight. The weight on drivers of the two classes of locomotives, compared, show, I think, for the balanced compounds, about

twenty per cent more, yet the disturbance and the effect on bridges were considerably less than in the case of the simple locomotive.

THE PRESIDENT: Is there any other gentleman who has information on this subject?

MR. FORSYTH: I will discuss the report briefly with respect to fuel economy.

The committee has stated one important conclusion here in regard to fuel economy, which is, that when developing 800 drawbar horse-power the compound uses 2.7 pounds of fuel per drawbar horse-power and the simple 4.85, a difference of 44 per cent. This is the prominent conclusion relating to the economy of the balanced compound locomotive. Now that is obtained when developing 800 horse-power, but it should be remembered that the four-cylinder compound is primarily and essentially a high-speed locomotive. It was developed for that purpose in France, and is running there on most of the State roads in high-speed service, and has been used in this country in high-speed service.

Mr. Vauclain's locomotive, the first four-cylinder unbalanced compound, made a remarkable record here between Atlantic City and Camden for high speed, but there has been little said about the economy of those engines at that high speed. If you will look at the curves in this report, you will find that on pages 14 and 15, that when you get up to 1,200 and 1,400, and 1,600 horse-power, the curve rises quite rapidly, and begins to approach the economy of the simple engine.

Now, if you will refer to the report which was made to this Association in 1906, and note the figures showing the effect of speed on the fuel economy of locomotives, you will find that on the New York Central balanced compound it was 2.75 pounds at 18 miles, 4.5 at 56 miles, and 4.65 at 75 miles. There are conditions there where the fuel consumption is doubled by increase in speed so that the criticism I would make of the committee's report is that this important element of speed should have been considered when they draw any conclusions in regard to fuel economy.

A very interesting point in regard to four-cylinder compound

locomotives is mentioned by the committee, and that is, the increased capacity, increased horse-power obtained, and I think the reason of that is because you can work more steam per minute through the cylinders than you can through simple cylinders, because you have such a large port area. Regardless of the economy you get an increased capacity for the same size engine, and for that reason I am surprised that Mr. Vauclain is ready to give up the compound type in favor of the superheater engine, because while the moderate superheating may slightly increase the economy, it will not add as much to the capacity of the locomotive as the four cylinders. There are places, I should think, where it is important to get heavy high-speed trains over the road, regardless of fuel economy, and that is the place where a four-cylinder compound ought to be a desirable machine.

Mr. C. A. Seley: I want to take issue with one of the statements of the last speaker, in that the superheater engine does not have a greater power than a non-superheater engine for the same size cylinder. It has been very conclusively demonstrated by the use of superheater engines, that even though by reason of poor coal and an imperfect superheat, resulting in a considerable decrease of normal boiler pressure, yet these superheating engines can take the train over the road at a speed which is marvelous. I think Mr. Vauclain has a very good basis for his preference for the superheater engine, for a number of classes of service.

Mr. Vauclain: If I may be permitted, I would like to add a few words.

Mr. Forsyth said he regretted I was willing to give up the balanced compound for a superheater engine. I do not give up anything. I am not built that way. If you will refer to this report, I think that you will find that some of the things which Mr. Forsyth mentioned have been considered. For instance, on page 12, Fig. 2 in the comparison of the steam consumption between the compound and simple locomotives, you will notice that the steam consumption of the single-expansion locomotive, and the compound locomotive, do approach each other at the same speed, but not the same horse-power. On the next page, 13,

the diagram showing the coal consumption between compound and single-expansion locomotives, the diagram is exactly the counterpart of what has been presented to this convention years and years ago, taken from actually indicated diagrams between compound and simple locomotives, indicating their economy, and you will notice in the single-expansion engine, the rise is even more rapid with the simple engine than with the compound when doing their duty. This is due to the increased exertion on the part of the boiler. You have got to burn considerably more coal on the same number of square feet of grate surface, and you have got to get an additional amount of steam out of the same square feet of heating surface.

It is true that compound locomotives are capable of hauling greater trains at high speeds than single-expansion locomotives, and for that reason many railroads are holding on to that class of power for that service; but I am absolutely convinced from my experience of the past few years that superheater locomotives possess that faculty to about the same extent, if not a greater extent, than the compound locomotives. I am not willing to-day to say that they do possess it to greater extent, but I think that they do to the same extent. That has been clearly demonstrated by the change of compound locomotives where the cylinders have become damaged, to superheat locomotives. We get practically the same efficiency, we get the same fuel economy, we do the same service, and we find another thing — that the compound locomotive shows its greatest economy over the superheater engine at the lower speeds, whereas at the higher speeds, where high horse-powers are given off, we get the highest efficiency from the superheater locomotive.

Mr. Seley: I am very sorry we have not our friend Dean Goss present to-day. I recall a personal remark made by him that across the water they compared the superheater engines with the compound, and not with the simple engine. They are not in the same class.

Mr. Sanderson: In connection with what the last speakers have said, about the use of the simple superheat engines, I reviewed a lot of indicator cards taken from engines of that kind recently, and in plotting the average mean effective pres-

sures, I found they showed a remarkably high average mean effective pressure throughout the stroke, more than I expected to find and more than I believe is common with the simple engines. It is natural it should be so, if you stop and consider it, and therein lies the increase in power developed by the engine for the same speeds and cut-offs.

MR. MANCHESTER: Referring to Mr. Vauclain's remarks about the good old days of the compound discussion I want to say that so far as the road with which I am connected is concerned, they are there to-day, and are doing all that was claimed for those engines in the good old days, and it is now common practice and history with us, so we do not do much talking about it. I have had our neighbors ask me frequently if we were taking the compound cylinders off our engines. I naturally had to answer them that we were not, and not only that, but that we were adding in some instances, to the number of compound engines we had for special service.

I was not able to give the committee very much information on the subject which they presented which was in reference to the balanced compound engines, as the balanced compound engines which we have, had been in service such a short time that no great amount of data about them was available. The information that I do have relative to the riding qualities of the balanced compound engine are all favorable to the engine, but so far as any other features are concerned, I am unable to discover that there is any advantage in the balanced compound engine that are not carried along with the four cylinder compound engine of the same size.

As to the greater power exerted by the compound engine, as is claimed in the paper, we had a very vivid and practical illustration of that. In the diagramming of our locomotives, we allow each locomotive a percentage. In a certain passenger service in our lines, engines which were classed as one hundred and eighteen per cent engines were not able to perform the work. They were simple engines. We put ninety per cent engines of the compound type there, and they have held that service up and given good results.

MR. NELSON: May I say a word in closing? This report, if

it has any value, presents to the Association comparative figures on compound and simple Atlantic type locomotives as found on a testing plant. Many people consider these laboratory figures, and in a sense they are; but you all understand how a locomotive is run, and the only practical difference between the testing-plant condition and the road condition is that we can run without variation in speed and without upsetting the fire and matters of that kind which often occur in road trials. Now, if this report is worth while it is simply in this: that it calls attention to the possibility of a very considerable saving in compounds. Mr. Vauclain has referred to the report as being *in memoriam,* and that is probably due to the general feeling that compound locomotives have not gotten into service in as large numbers as would apparently be warranted by such figures as those presented in this report. I think there are certain reasons why this is true. In the first place the handling of compounds is a different matter on the road and in the shop, as compared with more familiar types; and, all these things represent opposition to any new design. Furthermore in the last few years we have had before us the question of the superheater locomotive and it has appealed to many railroad men as a similar proposition. It is simply going to be a survival of the fittest; and, in the next two or three years I believe that we are going to settle on some type which will supplant the simple locomotive using saturated steam.

MR. DEVOY: There are two statements made by, perhaps, the greatest living American authority on compound locomotives, that even though it is the biggest thing that I am about to tackle, I feel as he did a few moments ago, that I am not at all afraid. In reading a paper before the Western Railroad Club some three years ago, and after very thoroughly testing the four-cylinder compounds as against the simple locomotives, I perfectly satisfied myself that the friends of the compound had done it more harm than all other people put together. And, now to go back to my point. Mr. Vauclain made the statement yesterday that a Mallet compound would do a horse-power on twenty pounds of dry steam per hour. I do not believe a locomotive has ever been built or ever will be built that will do it. In the tests that we have made — and they were careful — they were not

made wholly by the engineering department of the St. Paul Road, but the University of Wisconsin was called in in order to verify and determine that the results were correct. Twenty-five pounds of steam per horse-power is the best that we could get in regular average railroad service, and that statement will do the Mallet compound more harm, perhaps, than it will do it good, to say that any such economies will be obtained.

I have underlined a little portion of this report which I will read: "This saving of the compound over the simple locomotive is shown to be about forty-four per cent." Why, there would not be a simple locomotive on the American railroads to-day; and I want to say one thing, and I challenge any man, there never was a time when a balance compound locomotive was an absolute necessity on any road. A compound locomotive will save, generally, from eighteen to twenty-five per cent in fuel under all conditions. In determining the results between a class of simple engines and a class of compound locomotives in nearly the same service, it was found there was about twenty-one per cent fuel economy in one over the other, and that in the cost of repairs in one year the simple engine beat the compound $285.17 per year in money-saving, taking the cost of repairs as against the fuel economies. There are certain conditions and certain services that may demand a compound locomotive. There is no limitation — and now, perhaps, you will find fault with me in some of my statements — there is no balanced compound locomotive or simple locomotive of the same capacity that will take fifteen cars from Chicago and land them in St. Paul as against the old four-cylinder Vauclain locomotive; and, I want to say, that the balanced compound locomotive has not and never will show any economy over the four-cylinder Vauclain locomotives properly put together. It was not the fault of the Baldwin Locomotive Works that they were not properly put together, they were held to certain conditions so far as our road was concerned; but the one point I want to make is this: to go back to that statement the friends of the compound locomotive have done it more hurt than any one else in the world. The compound is all right as far as it goes, and when Mr. Vauclain tries to get a horse-power on twenty pounds of dry steam for a compound locomotive he is going to get into trouble.

MR. VAUCLAIN: Mr. Chairman, after the oratorical effort from the West, I want to say that I was correct yesterday in stating that a compound locomotive could do twenty pounds of dry steam per indicated horse-power, and in support of that testimony please refer to page 12 of this report and you will find balanced compound locomotives, which are proportioned in the same way as Mallet locomotives, using only 19.5 pounds of dry steam per indicated horse-power.

MR. DEVOY: If there is anything in this world I do love, it is just this sort of thing. I want to thank the gentleman for the oratorical part of it. I am not an orator, gentlemen. I want to quote from the representations of the Baldwin Locomotive Works of two years ago. We do something on the St. Paul Road other than oratory. We turned out ten engines last month and ten the month before and Mr. Manchester made the statement that they build a Vauclain engine in the Baldwin Locomotive Works to-day better than has ever been done. I want to tell you what I had in mind. It has been the practice of some of the representatives of the Baldwin Locomotive Works to find out about what we were doing, and I do not believe I have ever been afraid to take them out; the last time one of their Chicago representatives came out, he said, "Well, my boy, we are doing a whole lot better than I wish we were." So, I say again, it is not all oratory. All that we say to-day is, tell us the kind of locomotive you want and we will attempt to build it, and I want to tell you right here that we will keep some of them hustling to beat our engines, so that I take some pride in something besides the oratory, although I like a scrap. [Applause.]

MR. NELSON: I don't want too cold water thrown on statements in this report, as it is distinctly stated in two places in this report that those are testing-plant conditions. We have conducted road trials and we know the difficulties and we know we have got on the testing-plant conditions that must be controlled, and we are pretty safe in saying that these figures are right for the testing plant, but we do not say they are right for the road. Furthermore, the St. Louis tests, which are published partly on the authority of a committee from this Association, show they can be operated on twenty pounds.

Mr. G. E. Parks (Mich. Central R. R.): In connection with the compound, a two-cylinder compound owned by the Michigan Central R. R. was tested at St. Louis by the Pennsylvania R. R. Some time previous to this test we conducted a road test and the results compared very favorably with the figures obtained on the testing plant. For this reason I believe we do get a horse-power on less than twenty pounds of steam per hour.

Mr. Gilbert: One of the speakers spoke of the reduction in track disturbance. I would like to ask if that remark covered the horizontal as well as the vertical track disturbance.

Mr. Clark: The statement referred to the vertical disturbance.

The President: We will entertain a motion to dispose of this subject.

Mr. Seley: I move that the discussion be closed.

Motion seconded and carried.

The Secretary: Prof. A. W. Smith was not able to be present and he sent the paper by express to Professor Hibbard. Professor Hibbard had to leave yesterday morning and we have been unable to locate the paper on "The Training of Technical Men." I make the suggestion, when the paper is received, that it be printed in the Proceedings, after it is approved by the Executive Committee.

Mr. Henderson: I make that motion.

Motion seconded and carried.

INDIVIDUAL PAPER—THE TRAINING OF TECHNICAL MEN.

Prof. A. W. Smith, Cornell University: A technically trained man is one who understands the laws of nature and who can use his brain effectively for the solution of material problems. He may have graduated from a technical school, or he may have gained all his knowledge and power of accomplishment unaided. He is not marked exclusively by any university degree, but by his capacity to produce results. Though many strong men have gained themselves without the aid of teachers, yet the easiest way to gain technical training is to begin in a technical

school. As in all intellectual professions the training process continues throughout the entire working period of life; but an effective technical course should lay the firm foundations on which to build.

Thirty years ago it was hard for a technical graduate to get work in any kind of engineering. To-day the leaders in all kinds of engineering look to the technical schools to supply many of their efficient helpers.

The reasons for this are obvious. The engineering of the earlier time was simpler and the man trained in the actual practice, with little knowledge from the schools, could carry it on successfully. He was distinctly at an advantage compared with the man fresh from the technical school without practical experience. Moreover, the technical schools of the earlier time were undeveloped and the training lacked much in power-giving quality. When there was any advance into new fields the leadership fell to him who knew the way, or who could find it out, and to know or find out the way one must know mathematics and the laws of nature.

Thirty years ago there was no electrical engineering. To-day the achievements of electrical engineering are a wonder to all of us. The leaders in this development were men who knew physics and who could think effectively. After they conceived of the production of a desired result through the agency of electricity many men were able to come in to help with the materialization of the idea.

The history of the modern development of heat engines is similar; the pioneers in steam turbines and in internal combustion engines again were thinkers who had learned physics.

To appreciate the growth of the need for broadly trained men in the railroad work it is only necessary to compare the railroad shops of thirty years ago with those of the present. The latter, with their centralized power, their pneumatic, hydraulic, electrical and water-supply systems, demand from some one a working knowledge of the whole field of engineering. The former certainly made no such demand. The qualities of sound judgment and a capacity for handling men were necessary in the earlier time as well as now; this demand has changed

only because the problems are more extensive and the bodies of men engaged are larger.

With all the engineering development of thirty years, with the multiplication of the lines along which effective thinking may increase knowledge and usefulness, there has come a broadening of the fields for the technically trained man, together with increased effectiveness in the training. The schools have not always fully met the need and only eternal watchfulness and unremitting work will insure their meeting the growing needs of the future.

Starting with the understanding that the schools can only begin the technical training which is to continue throughout the active life of an engineer, the question comes — What is the best course that a technical school can give? It is not proposed to discuss here the entire technical course, but some details that are in process of change and development.

In all building the foundations must be solid if the structure is to be large and high. The technical school is chiefly concerned with the foundations of the technical man's training.

Since the engineer deals with matter and energy, it follows that he must know the laws that govern them. Physics and chemistry have been well taught in the technical schools from the beginning and have made the advance required by the development of engineering.

MATHEMATICS FOR THE ENGINEER.

But a knowledge of pure mathematics must precede the study of the laws of nature. Pure mathematics — in almost all cases — has been taught to engineering students by men whose life-work was pure mathematics. To such men pure mathematics is an end. The engineer needs pure mathematics as a means to produce an engineering result. The stress in the teaching has been laid on the things that were interesting to the teacher rather than upon the things that were useful to the student. It has been as if the student received an assortment of many tools adapted to use upon all sorts of rarely occurring operations, and with no skill in their use, instead of a few tools constantly needed, which he could use with great skill. The engineer needs a working knowledge of elementary mathematics through calculus, but

the vital thing is that it should be elementary and that it must be a *working* knowledge. The trouble in teaching pure mathematics has been recognized and very generally discussed for several years, and there is an awakening in all the technical schools to the need of betterment. The fault has usually been with the engineering teachers rather than with the teachers of mathematics. The writer has always found the latter anxious to modify their work so as to make it effective.

SHOPS.

Shop work is given in some of the secondary schools as a necessary element of every pupil's education. Trade schools prepare the pupil for earning a livelihood. The shop work in the technical schools has too often been a mixture of these two. The true function of shop instruction in a technical school is to give an understanding of shop processes and of the principles of manufacturing. If the technical student is worthy of his opportunity he is not preparing to earn his way through life by work at a trade. He needs to get ideas from the school shops instead of manual skill. If he is to design machines intelligently he must understand the processes by which they are produced. If he is to work in any high position in manufacturing he must know what is possible in producing machine parts of required quality in large or small quantities at low cost.

An effort has been made to work out these ideas in the shops of Sibley College. The foundry work will be given next year in the first year of the course so that the student may understand the use of patterns before he makes them in the second year. Two molding machines have been installed so that their advantages over hand molding may be demonstrated, for the production of large numbers of duplicate castings.

In the forge shop, together with the usual provision for hand forging, a drop-press has been installed which is operated by an expert as a demonstration for the students, who learn hand forging and see drop forging. It is thus easy to teach that very expensive dies for the drop press may greatly reduce the cost of forgings that are required in duplicate in large numbers.

In the machine shop the students learn to operate the standard machine tools and also either operate or see the operation of machines with turrets. The equipment includes a Jones & Lamson 2 by 24-inch flat turret lathe, a Cleveland ⅞-inch full automatic screw machine, a Bardons & Oliver 1¼-inch screw machine, and a Colburn 34-inch vertical boring mill with turret.

Forty speed lathes are under construction in the shops and every operation upon these lathes during construction is a manufacturing operation.

In connection with this work in the shops, a class-room course is given treating of the "Principles of Manufacturing," including manufacturing methods and cost keeping. Incidentally the student will acquire skill in the use of tools; but the prime object of the course is to contribute to his mental equipment.

If, after leaving school, a young man takes up a division of engineering, like railroading, with specialized shop work, he should spend time enough in the shops to become familiar with the methods. It is impossible to teach specialized work in the school shops — the school is concerned with "foundations." Moreover, the best place to learn applied engineering is where it is carried on for profit.

DRAWING AND MACHINE DESIGN.

In the technical schools of the past the object was to train men to design and construct machines. The development of engineering, however, has been such that only a few of the men who go into engineering work become designers of machines. Hence the question arises, "Shall a thorough course in drawing and design be given to all technical students?"

Although few engineers are called on to really design machines, yet nearly all must, sooner or later, pass judgment on the designs of others. It is believed that no training is as effective to form sound judgment in this line as a careful detailed study of the motion elements of machines and of the strength and stiffness of machine parts.

All students in Sibley College take the course in machine design. This course begins in the first year with machine sketching, the making of working drawings and descriptive geometry. In the second year the work is called "Empirical Design." There

are many machine parts in which strength or stiffness are not the governing factors of design. They have to be made stronger than necessary because of other conditions either of construction or operation. Such machine parts are not designed by any theory but by following precedents established by good practice. In the junior year careful applications of the mechanics of materials are made to the design of machine frames and other work in advanced design.

Three years' work finishes the design course and in the senior year the student is allowed to specialize in electrical engineering, or general power plant design, or in internal combustion engines or reciprocating steam engines or steam turbines, or naval architecture or in railway mechanical engineering. In all of these divisions the tendency is toward less drafting and more computing. This increases results and broadens the work.

TESTING LABORATORY.

The testing laboratory is one of the most important divisions of the technical school. Here the student not only learns how to make tests and to give a clear and orderly report, but he also gets a clearer conception of the meaning of efficiency and a better understanding of machines.

DESIGN OF ENGINEERING PROPERTIES.

As the single small stationary engines of the past have been replaced by the great concentrated power stations of the present; as the small shop of other days has grown into the great manufacturing establishments of to-day, need has come for a new kind of designer; the designer of great aggregations of machinery which may be called "engineering properties." This man is required to combine the machines designed by others so that raw material may be treated and finished products delivered at a minimum cost. In Sibley College this subject is treated in the senior year with special reference to power stations; but the principles involved may be extended to other properties. The separate elements of power stations are described and their functions are studied, and then, with conditions fully specified, problems are worked out to determine the combination that will give the best result. Every item that affects profit on operation is

considered and an effort is made to use the methods of the best practice. Previous to the present year problems were assigned to the class and worked outside the college and handed in. This year all the work has been carried on in computing periods. Sections of the class assembled in a large room equipped with tables and chairs for three-hour periods and, under the direct charge of an instructor, worked the problems. They were free to use reference books and to discuss the problems freely with each other and with the instructor. Effort was made to produce the conditions of an engineering office, and the result was very satisfactory.

This effort on the part of the technical schools to get near to practice is probably the most important movement of the present. It is impossible to produce exactly the conditions of practice in the schools; the shock of change must always come to a man going from graduation to work. But this shock should be reduced to a minimum. To accomplish this most effectively all teachers should be men of experience in practice, and their experience should be renewed at intervals by vacation work or by years off. The advance of engineering is so rapid that no man can teach engineering exclusively for many years without getting "out of date." Antaeus must touch the earth to get renewed strength.

BUSINESS ENGINEERING.

The business side of modern engineering needs many trained men. It may be they are needed for the sales department of a manufactory, or for negotiation of contracts for the design and construction of engineering properties, or it may be for the presenting of engineering schemes to capitalists or for any one of a thousand other duties.

Such men need an understanding of the elements of engineering, and they also need to be trained in such subjects as elementary economics, transportation, money and banking, wages and labor problems, the law concerning contracts, or the relations of master and servant, or water rights, etc. A course is needed which gives a part of the present engineering course with these other subjects. When a technical school is a part of a university the providing of this course would only involve selection and

rearrangement. Many young men in the past few years have completed the engineering course in Sibley College, not because it suited their need, but because it suited them more nearly than any other course. This demand for a course in engineering business is steadily increasing and nowhere is it more imperative than in connection with railroads. The demand is sure to be met.

GRADUATE SCHOOLS.

In subjects like History or Literature, if advances are to be made beyond the undergraduate work, the place for study is in libraries. The work is upon things that are completed and recorded in books. But if the work is upon a developing subject, one that is constantly changing, one in which all books are "out of date," the place for advanced work is where the development is actually taking place.

A graduate school of engineering could only be made successful if the conditions of practice were reproduced in the school. Even if this were possible it would involve a very great and unjustified expense. And so again the fact appears that the technical schools are concerned with the foundations of engineering.

NEED OF BROADER TRAINING FOR ENGINEERS.

As the work of the engineer has developed and increased, it has touched other interests at more points and the engineer himself has needed more and more to be a man of affairs. There has been increasing need for him to meet men in other professions, the legislator, the lawyer, the financier. If he is to meet these men effectively he must meet them on their own level, he must be a man of broad interests and of culture. Engineering is an intellectual profession demanding a strong active mind, and in this engineers do not lack; but there is need that the mind may be applied effectively to other things than engineering, and so the modern engineer, if he is to occupy one of the high places, needs not only a technical, but also a liberal training. In the effort to give adequate training in the fundamentals of engineering at Sibley College all subjects not directly related to engineering have been crowded out of the four-year course, and the graduates have been accused of narrow specialization. For some

years it has been possible for a student to spend six years in Cornell University taking the A. B. degree at the end of four years and the M. E. degree at the end of six years. Only a few have taken this course.

This year it was suggested that all students be required to take five years for the M. E. degree, and that they be required to spend one year on subjects in arts. This suggestion was not adopted because it would shut out a large body of earnest men who, because of lack of money, or lack of taste for arts work, would not take this five-year course. But though this course was not adopted as a required course, it will probably be offered as an option next year.

It is true that there is a tendency for the engineer to be narrow and it is also true that it is desirable for him to be a cultivated man, not only because it enables him to achieve more as an engineer, but because it helps him to live a fuller life.

Summarizing, it seems to the writer that the duty of the technical school is:

1. To give sound instruction in all subjects necessary to an understanding of the laws of nature.

2. To lead the student in all of the work toward logical and effective thinking.

3. To give as far as is possible the point of view of practice. That is, to show that the engineer is not justified in creating an engineering property unless it pays a profit; and to teach the methods of determining if the profit will be forthcoming.

4. To offer courses planned to prepare men for the business side of engineering.

5. To offer longer courses with opportunity to elect general subjects for greater breadth of training.

THE PRESIDENT: We will now call on the Auditing Committee for their report.

MR. POMEROY: I have to report that the committee has examined the books of the Association and found them correct in every particular.

Mr. Peck: I move the report be received and adopted.

Motion seconded and carried.

The President: The report of the Committee on Resolutions will now be received. Mr. Basford read the report.

REPORT OF COMMITTEE ON RESOLUTIONS.

Whereas, The Forty-first Convention of this Association has been one of the most successful in its history, the attendance being ten per cent greater than last year, and whereas, the exhibits occupied seven per cent more floor space, with corresponding improvement in value and in appearance: be it

Resolved, That the hearty thanks of the Association be extended to the President for his admirable address, the officers of the Association, and especially the Secretary, for the painstaking preparations and conscientious efforts in every detail of the conduct of the sessions; to the technical committees and authors of papers for their effective service; to the Committee of Arrangements for providing so satisfactorily for the meetings; to the railroads for courtesies extended; to the hotels and business men of Atlantic City for their entertainment to the Railway Supply Manufacturers' Association for their efforts to render the exhibits valuable and instructive; to the technical press in general for their interest and support and to the daily *Railroad Age-Gazette* for prompt reports of the discussions.

Whereas, The regular appearance of daily reports of discussions at these conventions for many years is due to the unselfish and untiring energy as well as the ability of Hugh M. Wilson in the publication of the daily *Railway Age;* Whereas Mr. Wilson has retired from journalism; as a mark of appreciation of these efforts: be it

Resolved, That the thanks of the Association be extended to him personally, together with best wishes for his continued prosperity, good health and happiness.

G. M. Basford,
L. R. Pomeroy,
A. E. Mitchell,
Committee.

The President: A motion to receive this report will be in order.

Mr. Peck: I move that the report be received and adopted.

Motion seconded and carried.

The President: The next in order is the election of officers.

Mr. Seley: In order to make a resolution, there has been

some little talk about the delay in receipt of the reports of not only this Association, but also the Master Car Builders; and I would like to say, as a most frequent visitor of the office of the Secretary, that it is due to the fault of the members and not of the Secretary. You can investigate that matter for yourselves, by looking up the date of the signature of the reports, and the very large, heavy reports were sent in at the last moment, with blue-prints to be produced, and that sort of thing, and a number of reports were not ready even at the very late date that the reports were made. I, therefore, move you, sir, that the Executive Committee advise the Secretary to have all reports of committees printed that are received by May 15 after same have been listed and approved by the Executive Committee; that the reports received after that date be printed and presented at the convention; also that a copy of this resolution be forwarded to the Executive Committee of the Master Car Builders for their information.

MR. WRIGHT: Those papers that come in after the 15th to be presented at the convention, or at the following convention?

MR. SELEY: No, at the convention; but we don't have the use of them prior to that.

MR. WRIGHT: That is the present practice.

MR. SELEY: I wish to explain that the Secretary held the reports that came in early for the late ones. And while there were some reports in his hands as early as the first of December, the majority of them came in pretty nearly the last of May.

MR. PECK: I would amend Mr. Seley's motion that the chairman of each one of the committees be advised of this resolution.

MR. WILDIN: I second Mr. Seley's motion.

THE PRESIDENT: I trust you will go further in the matter and give the motion attention, because it is very annoying and delaying and has delayed the business of the convention by having these reports come in so late. In many instances they can be in on time just as well.

Motion carried.

THE PRESIDENT: Now, the election of officers is the next business in order. The Secretary will read the Constitution.

The Secretary read Section I, Article 8, of the Constitution.

THE SECRETARY: The President has appointed the following Tellers:

As Collecting Tellers — E. W. Pratt and R. V. Wright.

As Counting Tellers — F. F. Gaines and L. R. Pomeroy.

THE PRESIDENT: We will listen to the report of the Tellers as to the President.

MR. F. F. GAINES: Mr. President, the count stands 80 votes, 5 scattered, 75 for Mr. H. H. Vaughan.

MR. ANGUS SINCLAIR: I move the vote for Mr. Vaughan be made unanimous, the Secretary to cast the ballot.

Motion seconded and carried.

The Secretary announced that he had cast the ballot of the Association for Mr. Vaughan as President.

MR. GAINES: For First Vice-President will report 65 votes, necessary to a choice 33 votes, 2 votes scattered, 67 votes for Mr. Wildin.

MR. SINCLAIR: I move that the nomination of Mr. Wildin be made unanimous and that the Secretary be instructed to cast the ballot.

Motion seconded and carried.

The Secretary announced that he cast the ballot as directed for Mr. Wildin as Vice-President.

MR. GAINES: The vote for Second Vice-President is 65: Mr. Curtis 4, Mr. Parish 9, Mr. Seley 6, Mr. Fuller 31, Mr. Muhlfeld 6, Mr. Howard 2, Mr. Rumney 1, Mr. Mitchell 1, Mr. Manchester 2, Mr. Clark 2, Mr. Bronner 1. This shows that there is no election, and a second ballot will have to be taken.

After the second ballot for Second Vice-President, Mr. Gaines announced the total vote to be 70, of which Mr. Fuller received 51 votes, Mr. Curtis 7, Mr. Parish 6, Mr. Muhlfeld 1, Mr. Seley 5.

MR. SINCLAIR: I move that the election of Mr. Fuller be

made unanimous and that the Secretary be instructed to cast the ballot.

Motion seconded and carried.

The Secretary announced that he had cast the ballot as directed.

MR. GAINES: The vote for Third Vice-President, total 69; Mr. Muhlfeld 53, Mr. Howard 1, Mr. Miller 1, Mr. Manchester 5, Mr. Bentley 2, Mr. Seley 3, Mr. Curtis 4.

MR. SINCLAIR: I move that the election of Mr. Muhlfeld be made unanimous and that the Secretary be instructed to cast the ballot.

Motion seconded and carried.

The Secretary announced that he cast the ballot for election of Mr. Muhlfeld as Third Vice-President.

THE PRESIDENT: You will now prepare your ballot for Treasurer, also for the three Executive Members. Messrs. Seley, Howard and Whyte are the three hold-overs.

MR. GAINES: The vote for Treasurer is as follows: Total 66, Mr. Sinclair 65, scattering 1.

MR. PRATT: I move that we make this vote unanimous.

Motion seconded and carried.

THE PRESIDENT: We will save a little time if a motion is made that the three receiving the highest number of votes be declared elected.

MR. PRATT: I make that motion.

Motion seconded and carried.

MR. GAINES: The vote for Executive Members is as follows: Mr. Bentley 37, Mr. Rumney 22, Mr. Curtis 21. They were the highest three.

MR. SINCLAIR: I move that the Secretary be instructed to cast a ballot for those three gentlemen.

Motion seconded and carried.

The Secretary announced that he cast a ballot for Messrs. Bentley, Rumney and Curtis.

THE PRESIDENT: Gentlemen, in surrendering the position of President, I wish to thank you all for your uniform forbearance in passing over my shortcomings as presiding officer. Whatever success we have had is owing entirely to this feature and I bespeak for my successor the same kindness and herewith turn over the gavel to Mr. Vaughan. [Applause.]

MR. VAUGHAN: Gentlemen, it is impossible for me to thank you properly for the honor you have conferred upon me, or explain to you my appreciation of and thanks for your action. While I have not, perhaps, been a member of the Association as long as some of the others of you, I do not think there is anybody who has a deeper interest in the well being of the Master Mechanics' Association than I have; and it will be my pleasure and endeavor to carry on as well as possible the work of those who have preceded me, and use my best endeavors for the prosperity and furtherance of the objects of this Society. [Applause.]

MR. ANGUS SINCLAIR: Mr. President, and gentlemen, I wish to propose a hearty vote of thanks to our retiring President, Mr. Wm. McIntosh. We can think of his work as efficient in every line that he has been engaged in for the Association, in his presiding over the meetings, in his work on the Executive Committee and his work as a general member of this Society. I am sure that every one heartily approves of the manner in which Mr. McIntosh has performed his duties, and I think it would be very proper to put this motion as a rising vote.

Motion seconded and carried by a rising vote.

PRESIDENT VAUGHAN: I introduce Mr. Walbank, the President of the Railway Supply Association, who has a very pleasant duty to perform.

MR. WALBANK: Mr. President, a very pleasant and profitable season of the annual convention of June, 1908, is about closed. We have met in business conditions, not as auspicious as in some previous years; but we have had a very satisfactory attendance and we have all had a good time and hope that next year we shall meet under brighter commercial skies.

The Supply Manufacturers' Association express, through me, their appreciation of the courtesy and attention shown to the

exhibits prepared for your two mechanical associations. I have a few words to say, with your kind permission, to your retiring President. Mr. McIntosh, the consciousness of honors deserved, of work faithfully and ably done, and of retirement, and the praise and affection of those whom you have served is yours. I am the glad agent of your admiring friends among the supply men, who bid me present this Past President's badge.

MR. McINTOSH: Mr. Walbank, as President of the Supply Men's Association, I thank you sincerely for this kind memorial of the occasion, and I want to say that no Frenchman will wear the badge of the Legion of Honor, or German wear the Iron Cross with any greater pride than I will wear this badge of the Master Mechanics' Association. I thank you all.

THE PRESIDENT: There being no more business a motion to adjourn is in order.

MR. MILLER: I move we adjourn.

Motion seconded and carried.

CIRCULAR RELATING TO LETTER BALLOT.

DEAR SIR,—At the convention of 1908 the following subjects were referred to letter ballot. Each question is given a number in order to better provide for voting. Each member is requested to vote " Yes " or " No " opposite the number on each question on the accompanying ballot slip, which corresponds with the numbers on the letter ballot, and mail it to the Secretary, 390 Old Colony Building, Chicago, Illinois.

A vote " Yes " will mean that the subject is to be adopted as a standard, and a vote " No " will mean that it is not to be so adopted. The votes will be counted September 5, 1908, and any votes received at the Secretary's office after that date will be excluded from the count. All votes must be either " Yes " or " No " to be counted in the result, as no qualified votes will be considered.

All references to changes in the standards refer to the Proceedings for 1907.

Where recommendations have been made that these standards be changed to conform to M. C. B. standards, it should be understood that the changes will be made in accordance with the standards of the Master Car Builders' Association as modified this year.

APPRENTICESHIP SYSTEM.

The Committee on the Apprenticeship System recommended a series of basic principles relating to the handling of apprentices, and suggested their adoption in lieu of the code adopted in 1898. These principles are as follows:

1. To develop from the ranks in the shortest possible time, carefully selected young men for the purpose of supplying leading workmen for future needs, with the expectation that those capable of advancement will reveal their ability and take the places in the organization for which they are qualified.

2. A competent person must be given the responsibility of the

apprenticeship scheme. He must be given adequate authority, and he must have sufficient attention from the head of the department. He should conduct thorough shop training of the apprentices, and in close connection therewith should develop a scheme of mental training, having necessary assistance in both. The mental training should be compulsory and conducted during working hours at the expense of the company.

3. Apprentices should be accepted after careful examination by the apprentice instructor.

4. There should be a probationary period before apprentices are finally accepted; this period to apply to the apprentice term if the candidate is accepted. The scheme should provide for those candidates for apprenticeship who may be better prepared as to education and experience than is expected of the usual candidate.

5. Suitable records should be kept of the work and standing of apprentices.

6. Certificates or diplomas should be awarded to those successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

7. Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

8. It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibility.

9. Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

10. Apprenticeship should be considered as a recruiting system, and greatest care should be taken to retain graduated apprentices in the service of the company.

1. Are you in favor of substituting the above principles for the present code of apprentice rules?

REVISION OF STANDARDS.

SCREW THREADS, BOLTS AND NUTS.

The Committee on Revision of Standards recommends that the word "hexagon" be prefixed to the words "nuts" in heading of the second column and "bolt heads" in the heading of the third column of the table on page 355, Proceedings 1907, and that the table be continued from 2 inches to include 3½-inch sizes, as follows:

SCREW THREADS.				HEXAGON NUTS.				HEXAGON BOLT HEADS.			
Diam. of Screw.	Threads per Inch.	Diam. at Root of Thread.	Width of Flat.	Short Diam. Rough.	Short Diam. Finish.	Thickness Rough.	Thickness Finish.	Short Diam. Rough.	Short Diam. Finish.	Thickness Rough.	Thickness Finish.
$2\frac{1}{4}$	$4\frac{1}{2}$	1.962	.0277	$3\frac{1}{2}$	$3\frac{7}{16}$	$2\frac{1}{4}$	$2\frac{3}{16}$	$3\frac{1}{2}$	$3\frac{7}{16}$	$1\frac{3}{4}$	$2\frac{3}{16}$
$2\frac{1}{2}$	4	2.176	.0312	$3\frac{7}{8}$	$3\frac{13}{16}$	$2\frac{1}{2}$	$2\frac{7}{16}$	$3\frac{7}{8}$	$3\frac{13}{16}$	$1\frac{5}{16}$	$2\frac{7}{16}$
$2\frac{3}{4}$	4	2.426	.0312	$4\frac{1}{4}$	$4\frac{3}{16}$	$2\frac{3}{4}$	$2\frac{11}{16}$	$4\frac{1}{4}$	$4\frac{3}{16}$	$2\frac{1}{8}$	$2\frac{11}{16}$
3	$3\frac{1}{2}$	2.629	.0357	$4\frac{5}{8}$	$4\frac{9}{16}$	3	$2\frac{15}{16}$	$4\frac{5}{8}$	$4\frac{9}{16}$	$2\frac{5}{16}$	$2\frac{15}{16}$
$3\frac{1}{4}$	$3\frac{1}{2}$	2.879	.0357	5	$4\frac{15}{16}$	$3\frac{1}{4}$	$3\frac{3}{16}$	5	$4\frac{15}{16}$	$2\frac{1}{2}$	$3\frac{3}{16}$
$3\frac{1}{2}$	$3\frac{1}{4}$	3.100	.0384	$5\frac{3}{8}$	$5\frac{5}{16}$	$3\frac{1}{2}$	$3\frac{7}{16}$	$5\frac{3}{8}$	$5\frac{5}{16}$	$2\frac{11}{16}$	$3\frac{7}{16}$

2. Are you in favor of the above changes?

SELLERS' STANDARD NUTS AND BOLTS.

The Committee on Revision of Standards recommends that the equation, shown on page 356, for calculating the dimensions for rough heads should be changed to read as follows:

Rough head = ¾ diameter of bolt plus 1-16 inch.

3. Are you in favor of this change?

DISTANCE BETWEEN BACKS OF FLANGES.

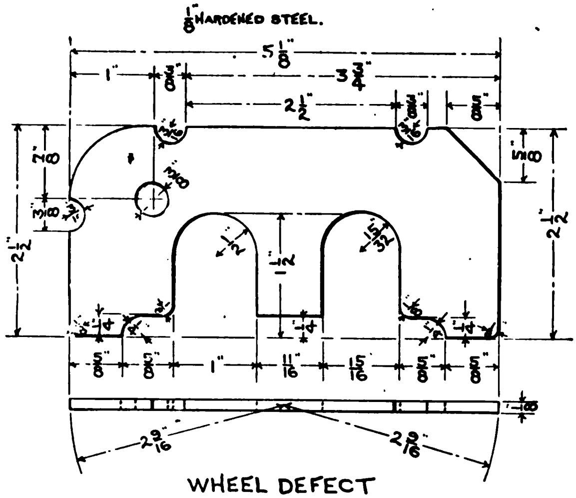
Page 357, Proceedings 1907.

The Committee on Revision of Standards recommends that the dimensions shown under this item on page 357, be applicable to steel-tired wheels, either engine truck, driver or tender wheels.

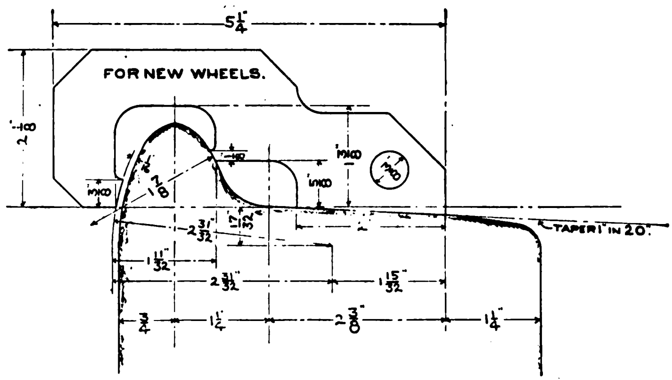
4. Are you in favor of this change?

GAUGES FOR CAST-IRON WHEELS.

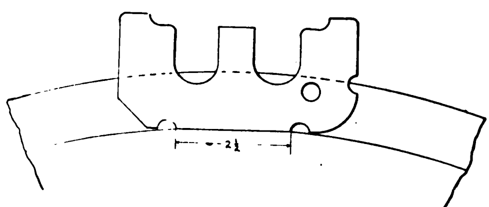
The Committee on Revision of Standards recommends that the gauges shown below, which are the same as those shown on pages 239, 240 and 241 of the Master Car Builders' Proceedings for 1907, except as modified to conform to those proposed in 1908, be made a standard and used when cast-iron wheels are applied to engine and tender.



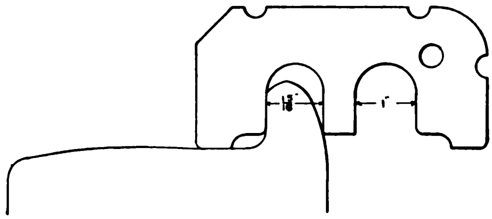
WHEEL DEFECT
AND
WORN COUPLER LIMIT GAUGE.



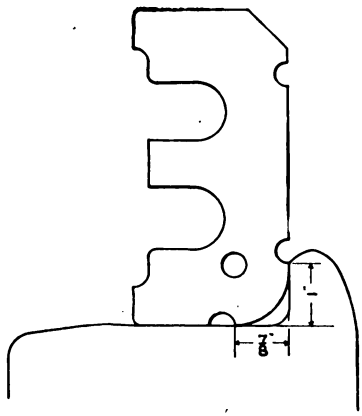
MAXIMUM FLANGE THICKNESS GAUGE.



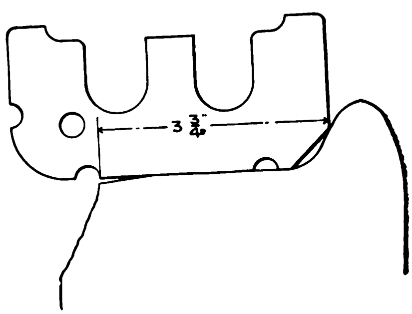
METHOD OF GAUGING SHELLED
AND FLAT SPOTS



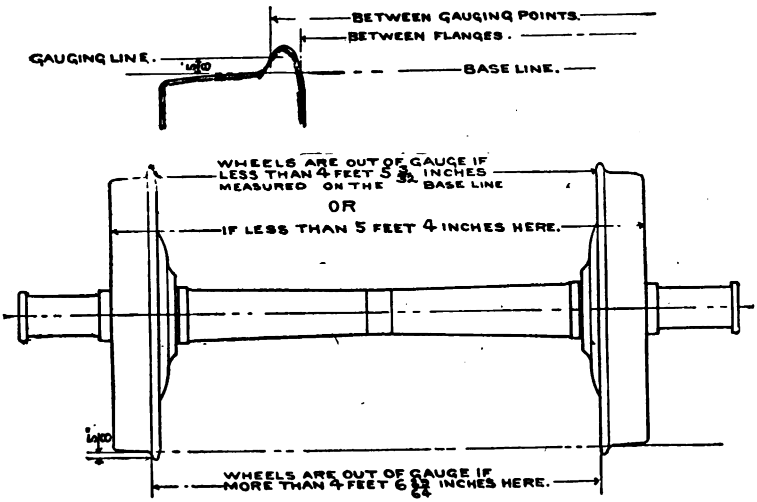
METHOD OF GAUGING WORN FLANGES.



METHOD OF GAUGING WORN FLANGES.



METHOD OF GAUGING CHIPPED RIMS.



5. Are you in favor of these additions?

LIMIT GAUGES FOR ROUND IRON.

The Committee on Revision of Standards recommends that the figures shown in the table on page 357, and the illustration of gauges, pages 357 and 358, be maintained, with the addition of limits of measurements of iron from 1⅜ inches up to 1⅞ inches in diameter, as follows:

Nominal Diameter of Rim, Inches.	Large Size End, Inches.	Small Size End, Inches.	Total Variation, Inches.
1⅜	1.3860	1.3640	.022
1½	1.5115	1.4885	.023
1⅝	1.6370	1.6130	.024
1¾	1.7625	1.7375	.025
1⅞	1.8880	1.8620	.026

Round iron 2 inches in diameter and over, should be rolled to the nominal diameter.

6. Are you in favor of the above additional limits of measurements?

DRIVING-WHEEL CENTERS.

The Committee on Revision of Standards recommends that the various sizes of wheel centers given in previous report be maintained as standard, as follows:

38 inches	66 inches	78 inches
44 "	70 "	82 "
50 "	72 "	86 "
56 "	74 "	90 "
62 "		

7. Are you in favor of maintaining these standards?

SECTION OF TIRES.

The Committee on Revision of Standards recommends that the radius of throat and taper of tread of tire for steel-tired wheels shown on Plate 1 be changed on tread to conform with the tread of wheels shown on Sheet J, Master Car Builders' Proceedings for 1907.

8. Are you in favor of the above change?

SHRINKAGE ALLOWANCE OF TIRES.

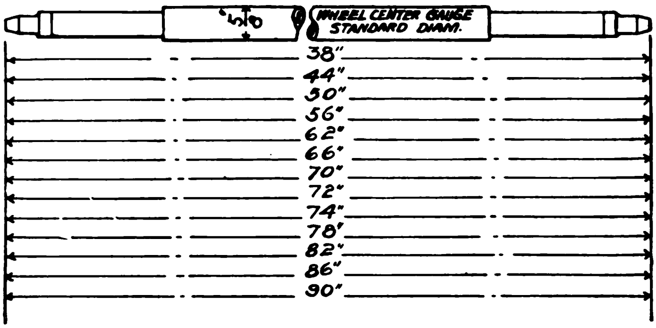
The Committee on Revision of Standards recommends that the shrinkage of tires should be on a uniform and proportionate basis, and that the dimensions shown in the diagram below, allowing 1-80 inch per foot in diameter of 38-inch centers, and 1-60 inch per foot in diameter of 90-inch centers, be adopted.

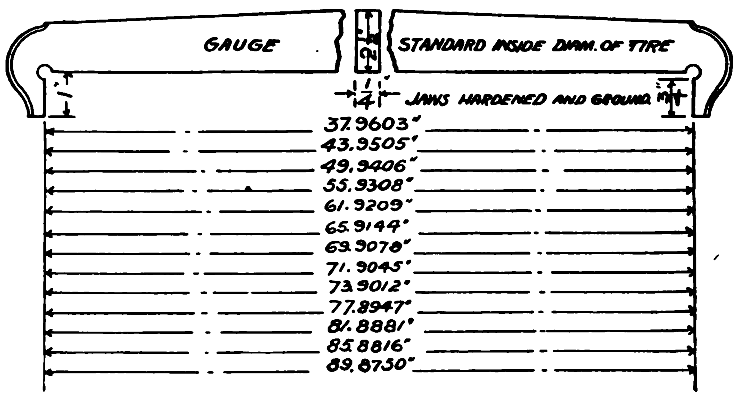
9. Are you in favor of these dimensions?

STANDARD MASTER GAUGES FOR TURNING WHEEL CENTERS AND BORING TIRES.

The Committee on Revision of Standards recommends the above heading for tire and wheel center gauges, and that the illustration for these gauges be made to include the dimensions for all the standard wheel centers and tires, as shown on next page.

STANDARD MASTER GAUGES FOR TURNING WHEEL CENTERS & BORING TIRES





10. Are you in favor of these changes?

BRIGGS' STANDARD WROUGHT-IRON PIPE AND THREADS.

Pages 386, 387.

The Committee on Revision of Standards recommends that this subject be combined with the one following, to read as follows:

STANDARD DIMENSIONS AND THREADS OF WROUGHT PIPE.

(The words "wrought pipe" in the above heading to include wrought iron and steel pipe.)

The dimensions of pipe and threads shown in the present printed table agrees with all manufacturers' lists, with the exception of the actual inside diameter of the following sizes of pipe:

1/8 inch	1 inch	8 inches
3/8 "	2½ inches	9 "
½ "	3 "	10 "

which are shown to be .001 of an inch larger in diameter than the manufacturers' list. It is recommended that the list be reprinted and that it include 11-inch and 12-inch pipe, as follows:

DIAMETER OF TUBE.			Thickness of Metal.	SCREWED ENDS.	
Nominal Inside.	Actual Inside.	Actual Outside.		Number of Threads per Inch.	Length of Perfect Screw.
Inches.	Inches.	Inches.	Inches.	No.	Inch.
1/8	.269	0.405	0.068	27	0.19
1/4	.364	0.540	0.088	18	0.29
3/8	.493	0.675	0.091	18	0.30
1/2	.622	0.840	0.109	14	0.39
3/4	.824	1.050	0.113	14	0.40
1	1.047	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.467	2.875	0.204	8	0.89
3	3.066	3.500	0.217	8	0.95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.981	8.625	0.322	8	1.46
9	8.937	9.625	0.344	8	1.57
10	10.018	10.750	0.366	8	1.68
11	11.000	11.750	0.375	8	1.79
12	12.000	12.750	0.375	8	1.90

11. Are you in favor of these changes?

AXLES.

Page 388.

The Committee on Revision of Standards recommends that this item be changed to read:

AXLES FOR LOCOMOTIVE TENDERS.

That the dimensions of axles shown in Plate I be made to conform to the latest Master Car Builders' dimensions for axles for corresponding capacity and that Plate I be changed accordingly.

12. Are you in favor of this change?

That the specifications and tests prescribed for axles by the Master Car Builders' Association be adopted as standard.

13. Are you in favor of this addition to our standards?

JOURNAL BOX BEARING AND PEDESTAL.

Page 388, Plate 14.

The Committee on Revision of Standards recommends that the pedestal for passenger cars with 3¾ by 7-inch journals, shown on Plate 14, and referred to in the first paragraph of above heading, be omitted.

14. Are you in favor of this omission?

That the journal boxes and contained parts for journals 3¾ by 7 to 5½ by 10 inches be made to conform to the Master Car Builders' standards.

15. Do you favor these changes?

CAST-IRON WHEELS.

The Committee on Revision of Standards recommends that the form of contract shown on page 398 be eliminated from the standards.

16. Do you favor this elimination?

That the service guarantee for cast-iron wheels, shown on page 399, be eliminated from the standards.

17. Do you favor this elimination?

That the designs, specifications, etc., for cast-iron wheels be made the same as the Master Car Builders' standards.

18. Do you favor these changes?

The question to be decided is: Do you favor the adoption as standard of the recommendations outlined in the preceding eighteen paragraphs? Answer "Yes" or "No" on inclosed voting slip and return same to the undersigned.

JOSEPH W. TAYLOR,
Secretary.

LETTER-BALLOT VOTING SLIP.

Ballots are to be cast by writing " Yes " or " No " opposite the question on this sheet and mailing it to the Secretary, 390 Old Colony Building, Chicago, Ill. Ballots will be counted September 5, 1908, and all ballots received after that date will be excluded from the count.

1.	Apprenticeship principles.	....
2.	Screw threads, bolts and nuts.	....
3.	Rough heads for bolts.	....
4.	Distance between backs of flanges.	....
5.	Gauges for cast-iron wheels.	....
6.	Limit gauges for round iron.	....
7.	Driving wheel centers.	....
8.	Section of tires.	....
9.	Shrinkage allowance of tires.	....
10.	Gauges for turning wheel centers and boring tires.	....
11.	Dimensions and threads for wrought iron pipe.	....
12.	Axles for locomotive tenders.	....
13.	Specifications and tests for axles.	....

14. Omission of pedestal drawings. ....

15. Journal boxes for 3¾ by 7 to 5½ by 10-inch journals. ....

16. Elimination of form of contract for wheels. ....

17. Elimination of guarantee for wheels. ....

18. Addition of designs, specifications, etc., for wheels. ....

(Name) ....

(Title and Road) ....

(Address) ....

RESULT OF LETTER BALLOT.

To the Members:

The letter ballot which closed September 5, 1908, resulted as follows:

No.	Subject.	Yes.	No.	Total.	Necessary to Adopti'n	Result.
1	Apprenticeship principles	118	15	133	89	Adopted.
2	Screw threads, bolts and nuts	135	......	135	90	"
3	Rough heads for bolts	122	12	134	89	"
4	Distance between backs of flanges	126	5	131	87	"
5	Gauges for cast iron wheels.	132	3	135	90	"
6	Limit gauges for round iron	133	2	135	90	"
7	Driving wheel centers	134	1	135	90	"
8	Section of tires	122	11	133	89	"
9	Shrinkage allowance of tires	128	8	136	91	"
10	Gauges for turning wheel centers and boring tires	129	7	136	91	"
11	Dimensions and threads for wrought iron pipe.	126	7	133	89	"
12	Axles for locomotive tenders	134	2	136	91	"
13	Specifications and tests for axles.	132	3	135	90	"
14	Omission of pedestal drawings	129	3	132	88	"
15	Journal boxes for 3¾ by 7 to 5½ by 10-inch journals	132	......	132	88	"
16	Elimination of form of contract for wheels.	124	7	131	87	"
17	Elimination of guarantee for wheels.	119	12	131	87	"
18	Addition of designs, specifications, etc., for wheels	127	5	132	88	"

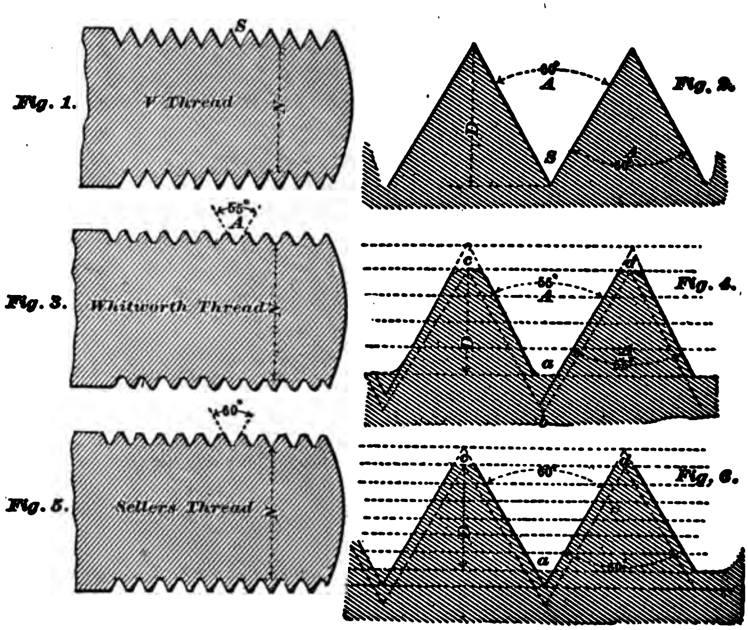
JOS. W. TAYLOR,

Secretary.

STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

SCREW THREADS, BOLT HEADS AND NUTS.

At the convention of 1870 the report of a committee recommending the United States Standard Screw Thread was adopted. The forms and dimensions of the threads are shown below:



SCREW THREADS. SELLERS' STANDARD.

Mr. Sellers, who proposed this system of screw threads, described it in an essay read before the Franklin Institute of Philadelphia, April 21, 1864, as follows:

"The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the accompanying diagram in which Figs. 1 and 2 — the latter on an exaggerated scale — represent a sharp thread, Figs. 3 and 4 a rounded top and bottom to the English proportion, and Figs. 5 and 6 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at sixty degrees, the same as the sharp thread, it being more readily obtained than fifty-five degrees; and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch; the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula:

$$\textit{Diameter} - \frac{1.299}{\textit{number of threads per inch.}}$$

At the convention of 1892 the Association adopted as standard the United States standard sizes of nuts and bolt heads.

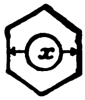
At the convention of 1903 the arrangement of these standards was made to conform to the arrangement as adopted by the Master Car Builders' Association.

The accompanying tables are reprinted from Mr. Sellers' essay. They give the proportions of his standard screw threads, nuts and bolt heads.

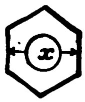
PROPORTIONS FOR UNITED STATES STANDARD SCREW-THREADS, NUTS AND BOLTS.

Screw-Threads.				Hexagon Nuts.				Hexagon Bolt-Heads.			
Diameter of screw.	Threads per inch.	Diameter at root of thread.	Width of flat.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.
1/4	20	.185	.0062	1/2	7/16	1/4	3/16	1/2	7/16	1/4	3/16
5/16	18	.240	.0074	19/32	17/32	5/16	1/4	19/32	17/32	19/64	1/4
3/8	16	.294	.0078	11/16	5/8	3/8	5/16	11/16	5/8	11/32	5/16
7/16	14	.344	.0089	25/32	23/32	7/16	3/8	25/32	23/32	25/64	3/8
1/2	13	.400	.0096	7/8	13/16	1/2	7/16	7/8	13/16	7/16	7/16
9/16	12	.454	.0104	31/32	29/32	9/16	1/2	31/32	29/32	31/64	1/2
5/8	11	.507	.0113	1 1/16	1	5/8	9/16	1 1/16	1	17/32	9/16
3/4	10	.620	.0125	1 1/4	1 3/16	3/4	11/16	1 1/4	1 3/16	5/8	11/16
7/8	9	.731	.0138	1 7/16	1 3/8	7/8	13/16	1 7/16	1 3/8	23/32	13/16
1	8	.837	.0156	1 5/8	1 9/16	1	15/16	1 5/8	1 9/16	13/16	15/16
1 1/8	7	.940	.0178	1 13/16	1 3/4	1 1/8	1 1/16	1 13/16	1 3/4	29/32	1 1/16
1 1/4	7	1.065	.0178	2	1 15/16	1 1/4	1 3/16	2	1 15/16	1	1 3/16
1 3/8	6	1.160	.0208	2 3/16	2 1/8	1 3/8	1 5/16	2 3/16	2 1/8	1 3/32	1 5/16
1 1/2	6	1.284	.0208	2 3/8	2 5/16	1 1/2	1 7/16	2 3/8	2 5/16	1 3/16	1 7/16
1 5/8	5 1/2	1.389	.0227	2 9/16	2 1/2	1 5/8	1 9/16	2 9/16	2 1/2	1 9/32	1 9/16
1 3/4	5	1.491	.0250	2 3/4	2 11/16	1 3/4	1 11/16	2 3/4	2 11/16	1 3/8	1 11/16
1 7/8	5	1.616	.0250	2 15/16	2 7/8	1 7/8	1 13/16	2 15/16	2 7/8	1 15/32	1 13/16
2	4 1/2	1.712	.0277	3 1/8	3 1/16	2	1 15/16	3 1/8	3 1/16	1 9/16	1 15/16
2 1/4	4 1/2	1.962	.0277	3 1/2	3 7/16	2 1/4	2 3/16	3 1/2	3 7/16	1 3/4	2 3/16
2 1/2	4	2.176	.0312	3 7/8	3 13/16	2 1/2	2 7/16	3 7/8	3 13/16	1 5/16	2 7/16
2 3/4	4	2.426	.0312	4 1/4	4 3/16	2 3/4	2 11/16	4 1/4	4 3/16	2 1/8	2 11/16
3	3 1/2	2.629	.0357	4 5/8	4 9/16	3	2 15/16	4 5/8	4 9/16	2 15/16	2 15/16
3 1/4	3 1/2	2.879	.0357	5	4 15/16	3 1/4	3 3/16	5	4 15/16	2 1/2	3 3/16
3 1/2	3 1/4	3.100	.0384	5 3/8	5 5/16	3 1/2	3 7/16	5 3/8	5 5/16	2 11/16	3 7/16

PROPORTIONS FOR SELLERS' STANDARD NUTS AND BOLTS.

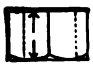


Rough Nut = one and one-half diameter of bolt + $\frac{1}{8}$.



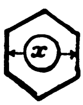
Finished Nut = one and one-half diameter of bolt + $\frac{1}{16}$.

Rough Nut = diameter of bolt.

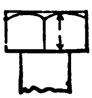


Finished Nut = diameter of bolt—$\frac{1}{16}$.

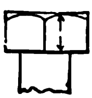
Rough Head = one and one-half diameter of bolt + $\frac{1}{8}$.



Finished Head = one and one-half diameter of bolt + $\frac{1}{16}$.



Rough Head = three-quarter times diameter of bolt + 1-16.



Finished Head = diameter of bolt—$\frac{1}{16}$.

SQUARE BOLT HEADS.

In 1899 the following dimensions for square bolt heads were adopted as standard:

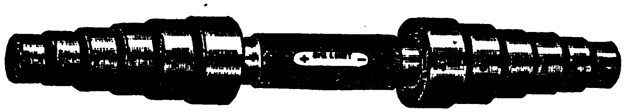
The side of the head shall be one and one-half times the diameter of the bolt, and the thickness of the head shall be one-half the side of the head.

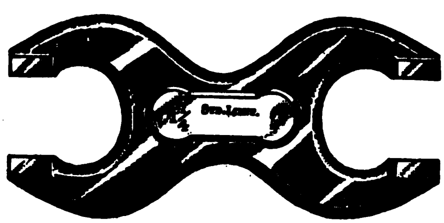
LIMIT GAUGES FOR ROUND IRON.

At the convention of 1884 the Pratt & Whitney limit gauges for round iron, shown below, were adopted as standard. (See page 168, report 1884.) Reaffirmed 1891 (see pages 160, 161, report 1891).

Nominal Diameter. Of Iron. Inches.	Large Size, End. Inches.	Small Size, End. Inches.	Total Variation. Inches.
1/4	.2550	.2450	.010
5/16	.3180	.3070	.011
3/8	.3810	.3690	.012
7/16	.4440	.4310	.013
1/2	.5070	.4930	.014
9/16	.5700	.5550	.015
5/8	.6330	.6170	.016
3/4	.7585	.7415	.017
7/8	.8840	.8660	.018
1	1.0095	.9905	.019
1 1/8	1.1350	1.1150	.020
1 1/4	1.2605	1.2395	.021
1 3/8	1.3860	1.3640	.022
1 1/2	1.5115	1.4885	.023
1 5/8	1.6370	1.6130	.024
1 3/4	1.7625	1.7375	.025
1 7/8	1.8880	1.8620	.026

Round iron 2 inches in diameter and over should be rolled to the nominal diameter.





DISTANCE BETWEEN BACKS OF FLANGES OF STEEL-TIRED ENGINE TRUCK, DRIVER OR TENDER WHEELS.

At the convention of 1884 a motion prevailed that the standard distance between the backs of tires for tender locomotive truck and driving wheels be not less than 4 feet 5⅜ inches, nor more than 4 feet 5½ inches. (See page 26, report 1884.) Modified in 1903. See report of Committee on Revision of Standards.

In 1908 the above standard was made applicable to steel-tired engine

truck, driver or tender wheels. For gauges for cast-iron wheels see plates 14 and 15.

GAUGES FOR CAST IRON WHEELS.

In 1908 a wheel-defect gauge and maximum flange-thickness gauge, also method of gauging, were adopted as standard, to be used when cast-iron wheels are applied to engine and tender. See Sheet M. M. 14.

SECTION OF TIRE.

At the convention of 1893 the forms of tires shown on Plate 1 were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.

In 1908 the section of tire was modified, as shown on Sheet M. M. 1.

DRIVING WHEEL CENTERS AND SIZES OF TIRES.

At the convention of 1886 the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter.

In 1893 the following sizes were added to the standards: 70, 74, 78, 82, 86 and 90 inches.

In 1907, as a result of letter ballot, 72 inches was adopted as a standard size.

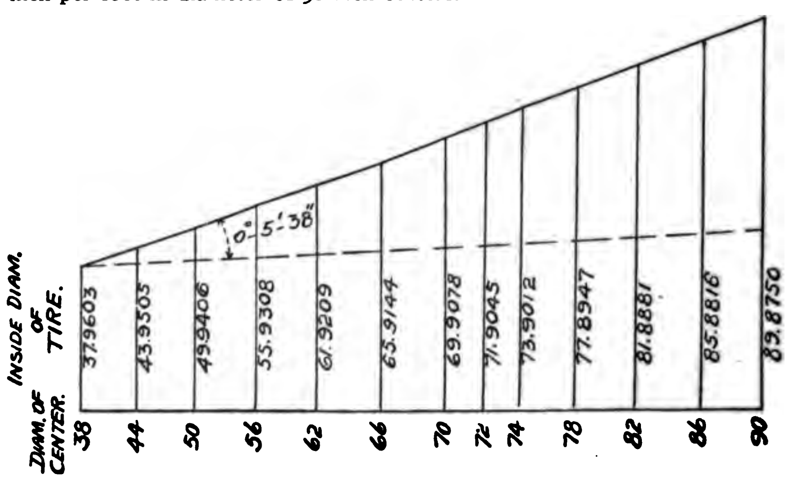
SHRINKAGE ALLOWANCES FOR TIRES.

In 1907, as a result of letter ballot, the following shrinkage allowances were adopted as standard:

For cast-iron and cast-steel centers less than 66 inches in diameter, 1-80 inch per foot in diameter.

For cast-iron and cast-steel centers 66 inches and over in diameter, 1-60 inch per foot in diameter.

In 1908 the dimensions shown in diagram below were adopted as standard, allowing 1-80 inch per foot in diameter of 38-inch centers, and 1-60 inch per foot in diameter of 90-inch centers.

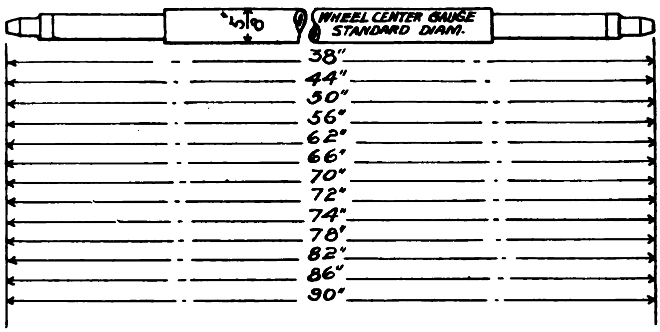


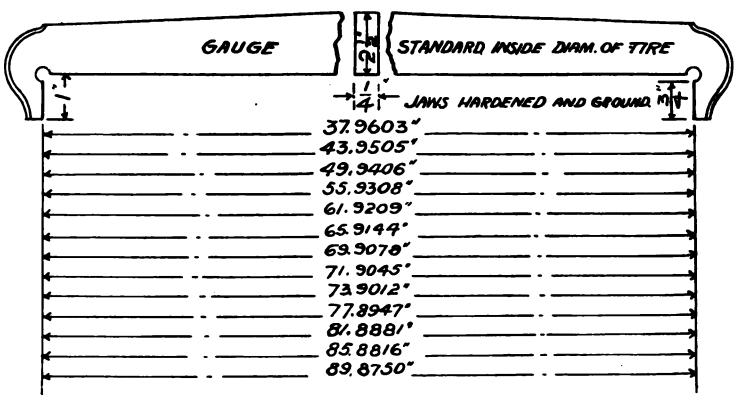
STANDARD MASTER GAUGES FOR TURNING WHEEL CENTERS AND BORING TIRES.

At the Twentieth Annual Convention the recommendations of a committee were adopted, making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Connecticut, standards of the Association.

In 1908 the illustrations of the gauges were made to include the dimensions for all the standard wheel centers and tires.

STANDARD MASTER GAUGES FOR TURNING WHEEL CENTERS & BORING TIRES





SPOKES.

In 1907, as a result of letter ballot, the following standards were adopted:

In order to properly support the rim and resist the tire shrinkage, spokes should be placed from 12 to 13 inches apart from center to center, measured on the outer circumference of the wheel center.

Spokes at crank hub should not be located at center line of wheel, but on either side, so as not to bring a short spoke directly in line with crank-pin hub. Section of spokes at large end to have an area of from

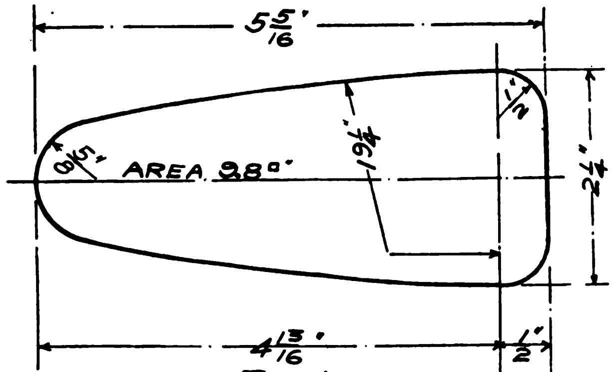


FIG. 1.

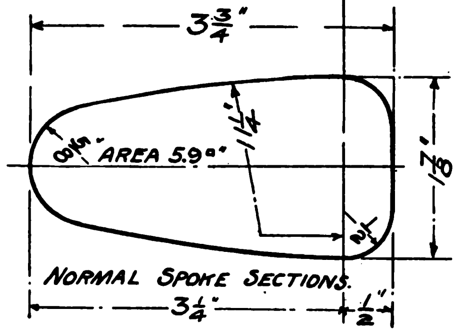


FIG. 2.

9 to 10 inches, with form as shown in Fig. 1. Section of spoke at small end to have an area of from 5¾ to 6 inches, with form as shown in Fig. 2. The sections shown herewith are taken at the base of the fillets uniting the spoke to the hub and rim.

DRIVING-WHEEL CENTERS.

In 1907 the following standards were adopted by letter ballot:

Cast-steel driving-wheel centers should preferably be uncut and shrinkage slots omitted; if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal should be used.

For wheel centers 60 inches and over, when the permissible total weight of the locomotive will allow, the rims should preferably be cast solid without cores, so as to obtain the maximum section and have full bearing of tires; the section in square inches should be approximately .45 of the sectional area of the tire when new.

The section of rim for wheel centers without retaining rings shall be of the form shown below:

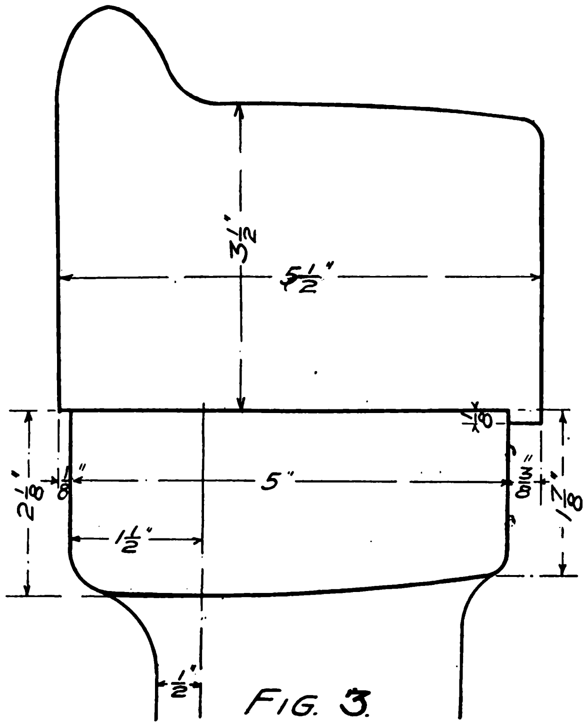


FIG. 3.

The standard distance between hubs shall be 55 inches.

SPECIFICATION FOR BOILER AND FIRE-BOX STEEL.

MADE BY THE OPEN HEARTH PROCESS.

Adopted in 1894. Revised 1904.

1. SPECIAL REQUIREMENTS FOR SHELL SHEETS.

This grade of steel is known to the trade as flange or boiler steel The desired tensile strength is 60,000 pounds per square inch, with minimum and maximum limits 55,000 and 65,000 pounds. The elongation in eight inches shall not be less than twenty-five per cent for sheets three-quarters of an inch thick or under. For thicker sheets, deduct one per cent from specified elongation for each one-eighth inch additional thickness.

2. CHEMICAL REQUIREMENTS FOR SHELL SHEETS.

	Per cent.
Phosphorus shall not exceed (acid)	0.06
Phosphorus shall not exceed (basic)	0.04
Sulphur shall not exceed	0.05
Manganese	0.30 to 0.60

3. SPECIAL REQUIREMENTS FOR FIRE-BOX STEEL.

The desired tensile strength is 57,000 pounds per square inch, with minimum and maximum limits 52,000 and 62,000 pounds. The elongation in eight inches shall not be less than twenty-six per cent.

4. CHEMICAL REQUIREMENTS FOR FIRE-BOX SHEETS.

	Per cent.
Carbon	0.15 to 0.25
Phosphorus shall not exceed (acid)	0.04
Phosphorus shall not exceed (basic)	0.03
Sulphur shall not exceed	0.04
Manganese	0.30 to 0.50

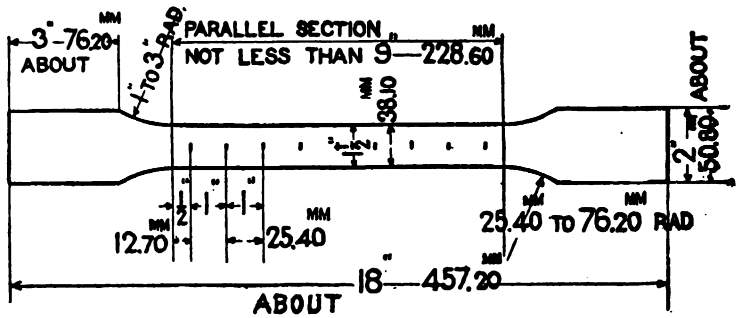
GENERAL REQUIREMENTS.

5. BENDING TESTS.

Test specimens for this purpose shall be 1½ inches wide, and for material ¾ inch or less in thickness shall be of the same thickness as that of the finished sheet. For sheets more than ¾ inch thick, the bending-test specimen may be ½ inch thick. The sheared edges of bending-test specimens may be milled or planed. The cold bending test shall be made on the material in the condition in which it is to be used. The specimen for quench bending test shall be heated to a light cherry red, as seen in the dark, and quenched in water having a temperature between 80° and 90° F. Boiler steel and fire-box steel, before and after quenching, shall bend cold 180° flat on itself without fracture on the outside of the bent portion. The bending test may be made by pressure or by blows. One cold bending specimen and one quenched bending specimen will be furnished from each plate as it is rolled. The homogeneity tests for fire-box steel shall be made on one of the broken tensile test specimens.

6. SPECIMENS FOR TENSILE TEST.

Two tensile test specimens will be furnished from each plate as it is rolled. The standard test specimen of 8-inch gauged length shall be used for the tensile test. The standard shape of the test specimens shall be as shown by the following sketch:



PIECE TO BE OF SAME THICKNESS AS THE PLATE.

7. HOMOGENEITY TEST.

The homogeneity test for fire-box steel is made as follows: A portion of the broken tensile test specimen is either nicked with a chisel or grooved on a machine, transversely about a sixteenth of an inch deep, in three places about two inches apart. The first groove should be made on one side, two inches from the square end of the specimen; the second, two inches from it on the opposite side, and the third, two inches from the last and on the opposite side from it. The test specimen is then put in a vise, with the first groove about a quarter of an inch above the jaws, care being taken to hold it firmly. The projecting end of the test specimen is then broken off by means of a hammer, a number of light blows being used, and the bending being away from the groove. The specimen is broken at the other two grooves in the same way. The object of this treatment is to open and render visible to the eye any seams due to failure to weld up, or to foreign interposed matter, or cavities due to gas bubbles in the ingot. After rupture, one side of each fracture is examined, a pocket lens being used if necessary, and the length of the seams and cavities is determined. The broken specimen shall not show any single seam or cavity more than ¼ inch long in either of the three fractures.

8. VARIATION IN WEIGHT.

The variation in cross section or weight of more than two and one-half per cent from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations:

Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ per cent variation above or 2½ per cent below the theoretical weight. When 100 inches wide and over five per cent above or five per cent below the theoretical weight.

Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following:

Up to 75 inches wide, 2½ per cent above or 2½ per cent below the theoretical weight. Seventy-five inches wide up to 100 inches wide, five per cent above or three per cent below the theoretical weight. When 100 inches wide and over, ten per cent above or three per cent below the theoretical weight.

For all plates ordered to gauge there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table:

9. TABLE OF ALLOWANCES FOR OVERWEIGHT FOR RECTANGULAR PLATES WHEN ORDERED TO GAUGE.

Plates will be considered up to gauge if measuring not over 1-100 inch less than the ordered gauge.

The weight of 1 cubic inch of rolled steel is assumed to be 0.2833 pound.

PLATES ¼ INCH AND OVER IN THICKNESS.

Thickness of plate Inch.	Width of plate. Up to 75 inches. Per Cent.	75 to 100 inches. Per Cent.	Over 100 inches. Per Cent.	Over 115 inches. Per Cent.
1/4	10	14	18	....
5/16	8	12	16	....
3/8	7	10	13	17
7/16	6	8	10	13
1/2	5	7	9	12
9/16	4 1/2	6 1/2	8 1/2	11
5/8	4	6	8	10
Over 5/8	3 1/2	5	6 1/2	9

PLATES UNDER ¼ INCH IN THICKNESS.

Thickness of plate. Inch.	Width of plate. Up to 50 inches. Per cent	50 inches and above. Per cent.
1/8 up to 5/32	10	15
5/32 " 3/16	8 1/2	12 1/2
3/16 " 1/4	7	10

10. BRANDING.

Each sheet shall be stamped with the melt number and maker's name, and the test specimens cut from it shall be stamped with separate identifying marks or numbers, as may be specified by the purchaser.

11. INSPECTION.

The inspector, representing the purchaser, shall have all reasonable facilities afforded to him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications.

SPECIFICATIONS FOR IRON LOCOMOTIVE BOILER TUBES.

Adopted in 1894. Revised June, 1904.

1. Tubes are to be made of knobbled, hammered charcoal iron, lapwelded.

2. Tubes must be of uniform thickness throughout, except at weld, where an additional thickness of .015 will be allowed. They must be circular within .02 inch, and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch.

3. The minimum weights for tubes of various diameters and thicknesses are given in the following table:

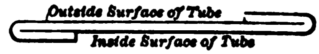
Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1.65
	" 12	.110	1.89
	" 11	.125	2.07
	" 10	.135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.17
	" 11	.125	2.38
	" 10	.135	2.64
2¼ inch	" 13	095	2.16
	" 12	.110	2.46
	" 11	125	2.70
	" 10	.135	2.99
2½ inch	" 12	.110	2.73
	" 11	.125	3.02
	" 10	.135	3.37

SURFACE INSPECTION.

4. Tubes must have a smooth surface, free from all laminations, cracks, blisters, pits and imperfect welds. They must be free from bends, kinks and buckles, and from evidence of unequal contraction in cooling or injury in manipulation.

PHYSICAL TESTS.

5. Bending Tests.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80° F., shall bend in opposite directions at each end, as shown in sketch below, without cracks or flaws, and when nicked and broken by slight blows, these strips must show a fracture wholly fibrous.



6. EXPANDING TEST.— Sections of tubes 12 inches long shall be heated a length of 5 inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test, care must be taken to see that the end of the tube is smoothly trimmed.

7. One tube is to be tested, as required in paragraphs 5 and 6, in each lot of 250 tubes or less.

8. CRUSHING TEST.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction and without cracking or bending at weld.

9. HYDRAULIC TEST.— Before shipping, each tube must be tested by manufacturer to 500 pounds per square inch, and each tube must be plainly marked in the middle: "Knobbled charcoal, tested to 500 pounds pressure."

10. In addition to the above tests, tubes which, when inserted into boilers, split or break while being expanded or beaded, and also individual tubes which fail to pass surface inspection will be rejected and returned to the makers at their expense.

11. ETCHING TEST.— In case of doubt as to the quality of material, the following test shall be made to detect the presence of steel. A section of tube, turned or ground to a perfectly true surface on the end, will be polished free from dirt or cracks, and the end of the tube will be suspended in a bath of nine parts water, three parts sulphuric acid and one part hydrochloric acid. The bath will be prepared by placing water in a porcelain dish, adding the sulphuric and then the hydrochloric acid. The chemical action must be allowed to continue until the soft parts are sufficiently dissolved so that the iron tube will show a decided ridged surface, with the weld very distinct, while the steel tube will show a homogeneous surface.

SPECIFICATION FOR SEAMLESS, COLD DRAWN STEEL LOCOMOTIVE BOILER TUBES.

1. Tubes are to be cold drawn, seamless and made of open hearth steel. It is desired that the steel from which the tubes are manufactured should have the following chemical composition:

	Per cent.
Carbon	.15 to .20
Manganese	.45 to .55
Sulphur, below	.03
Phosphorus, below	.03

Tubes containing more than .03 phosphorus or sulphur will be rejected.

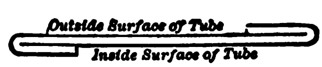
2. Tubes must be of uniform thickness throughout. They must be circular within .02 of an inch and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch. They must be free from bends, kinks and buckles.

3. The minimum weights of the tubes of various diameters and thicknesses are given in the following table:

Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1.69
	" 12	.110	1.92
	" 11	.125	2.15
	" 10	.135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.19
	" 11	.125	2.47
	" 10	.135	2.65
2¼ inch	" 13	.095	2.16
	" 12	.110	2.48
	" 11	.125	2.80
	" 10	.135	3.01
2½ inch	" 12	.110	2.73
	" 11	.125	3.04
	" 10	.135	3.41

PHYSICAL TESTS.

4. Bending Test.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80 degrees F., shall bend in opposite directions at each end, as shown in sketch below without cracks or flaws.



5. EXPANDING TEST.— Sections of tubes 12 inches long shall be heated a length of five inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test care must be taken to see that the end of the tube is smoothly trimmed.

6. CRUSHING TEST.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction.

7. FLATTENING TEST.— A test piece of tube 6 inches long, when flattened lengthwise cold until the sides are separated by a distance equal to the gauge of the tube, must not show any splits or cracks.

8. One tube is to be tested as required in paragraphs 4, 5, 6 and 7 in each lot of 250 tubes, or less.

9. Each tube must be subjected by the manufacturer to an internal pressure of 1,000 pounds to the square inch and must be plainly stenciled, "Seamless Steel Tubes, tested to 1,000 pounds."

SPECIFICATION FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed .... .05 per cent.
Sulphur, not to exceed .... .05 per cent.
Manganese, not to exceed .... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation in two inches — not less than 20 per cent.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half-way between the center and the outside, the hole made by the drill to be not more than 2 inches in diameter nor more than 4½ inches deep. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.)

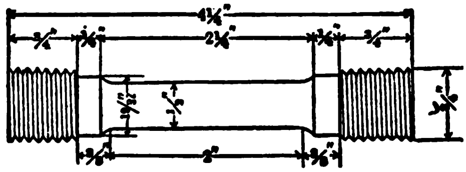


FIG. I.

Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

5. Each axle must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

6. All axles must be free from seams, pipes and other defects, and must conform to drawings accompanying these specifications.

7. Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers.

8. Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed...................... .05 per cent.
Sulphur, not to exceed......................... .05 per cent.
Manganese, not to exceed...................... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation — not less than 20 per cent in two inches.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be cut cold from the forging, or full-sized prolongation of same, parallel to the axis of the forging and half-way between the center and the outside.

5. The standard turned specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See

Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

6. Each forging must have heat number and name of manufacturer plainly stamped on one end with figures not less than 3/8 inch high, and have order number plainly marked with white lead.

INSPECTION.

7. All forgings must conform to drawings which accompany these specifications, and be free from seams, pipes and other defects.

8. Any forgings failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR STEEL BLOOMS AND BILLETS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

PHYSICAL REQUIREMENTS.

2. Grade "A":
   Tensile strength, 70,000 lbs. per square inch.
   Elongation in two inches, 20 per cent.

3. Grade "B":
   Tensile strength, 80,000 lbs. per square inch.
   Elongation in two inches, 17 per cent.

CHEMICAL ANALYSIS.

4. Grade "A":

Carbon	.25 to .40 per cent.
Phosphorus, not to exceed	.06 per cent.
Sulphur, not to exceed	.06 per cent.
Manganese, not to exceed	.60 per cent.

5. Grade "B":

Carbon	.35 to .50 per cent.
Phosphorus, not to exceed	.05 per cent.
Sulphur, not to exceed	.05 per cent.
Manganese, not to exceed	.60 per cent.

TESTS.

6. One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, 1/2 inch in diameter and

2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

7. Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than 3/8 inch, and have order number plainly marked with white lead.

INSPECTION.

8. Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than 1/2 inch will be rejected.

9. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers.

10. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is intended for rod straps and miscellaneous forgings.

Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

SPECIFICATIONS FOR FOUNDRY PIG IRON.

At the convention of 1906 specifications for foundry pig iron were proposed, and on reference to letter ballot were adopted as standard. They are as follows:

The material desired under this specification is an open-grain foundry pig conforming to and graded by the following detail specifications:

Combined carbon	.40 to .70 per cent.
Manganese	.40 to .80 per cent.
Phosphorus	.40 to .80 per cent.
Sulphur, not over	.06 per cent.

The grades are determined by the amount of silicon, in accordance with the attached schedule:

Grade No. 1, silicon....................	3.00 to 2.50 per cent.
Grade No. 2, silicon....................	2.50 to 2.00 per cent.
Grade No. 3, silicon....................	2.00 to 1.50 per cent.
Grade No. 4, silicon....................	1.50 to 1.00 per cent.

Each carload, or its equivalent, shall be considered as a unit. At least

one pig shall be selected at random for each four tons of every carload and so as to fairly represent it.

Drillings shall be taken so as to fairly represent the fracture surface of each pig, and the sample analyzed shall consist of an equal quantity of drillings from each pig, well mixed and ground before analysis.

In case of disagreement between buyer and seller, an independent analyst, to be mutually agreed upon, shall be engaged to sample and analyze the iron. In this event one pig shall be taken to represent every two tons.

The cost of this sampling and analysis shall be borne by the buyer if the shipment is proved up to specifications, and by the seller if otherwise.

SPECIFICATIONS FOR LOCOMOTIVE CYLINDER CASTINGS, CYLINDER BUSHINGS, CYLINDER HEADS, STEAM CHESTS, VALVE BUSHINGS AND PACKING RINGS.

At the convention of 1906 the following specifications were proposed, and on reference to letter ballot were adopted as standard:

The material used in such castings must conform to the following specifications:

Silicon	1.25 to 1.60 per cent.
Phosphorus	.50 to .80 per cent.
Sulphur	.06 to .10 per cent.
Manganese	.30 to .60 per cent.
Combined carbon	.50 to .70 per cent.
Graphite carbon	2.75 to 3.25 per cent.

Tensile strength, 25,000 lbs. per sq. inch minimum.

Transverse strength, 3,000 lbs. minimum on 1¼-inch round bar, 12 inches between supports.

Deflection, .10 inch minimum on transverse test.

Shrinkage, ⅛ inch in 1 foot as a maximum.

The quality of the iron going into castings under specification shall be determined by means of the "arbitration bar." This is a bar 1¼ inches in diameter and 15 inches long. It shall be prepared as stated further on and tested transversely. The tensile test is not recommended, but in case it is called for it may be made from any of the broken pieces of the transverse test. The expense of the tensile test shall fall on the purchaser.

The tensile test piece should be prepared with threaded ends, 1¼ inches in diameter, and with a central neck of 0.8 inch diameter, 1 inch between shoulders, with a 7-32-inch radius at the shoulders, the shoulders being 1 inch in diameter and ¼ inch in length to the thread, the total length of piece being about 3½ inches.

Two sets of two bars shall be cast from each heat, one set from the

first and the other set from the last iron going into the castings. Where the heat exceeds 20 tons an additional set of two bars shall be cast for each 20 tons or fraction thereof above this amount. In case of a change of mixture during the heat one set of two bars shall also be cast for every mixture other than the regular one. Each set of bars is to go in a single mold. The bars shall not be rumbled or otherwise treated, being simply brushed off before testing.

The transverse test shall be made on all the bars cast with supports 12 inches apart, load applied at the middle, and deflection at rupture noted. One bar of every two of each set made must fulfil the requirements to permit acceptance of the castings represented.

The bars shall be molded two in a flask and cast on end; the bottom of the bar being 1-16 inch smaller in diameter than the top, to allow for draft. Pattern shall not be rapped before withdrawing. The flask is to be rammed up with green molding sand, a little damper than usual, well mixed and put through a No. 8 sieve with a mixture of 1 to 12 bituminous facing. The mold shall be rammed evenly and fairly hard, thoroughly dried and not cast until it is cold. The test bar shall not be removed from the mold until cold enough to be handled.

The rate of application of the load shall be from 20 to 40 seconds for a deflection of 0.10 inch.

Borings from the broken pieces of the arbitration bar shall be used for the chemical determinations. One determination for each mold shall be required.

For cylinder heads, steam chests and packing rings the silicon must run between 1.60 and 1.80 per cent, the other elements remaining as above. If cylinder castings are to be bushed from the start and also have valve bushings or false valve seats, they should be made of this latter grade of iron.

SPECIFICATIONS AND TESTS FOR CAST-IRON WHEELS.

At the convention of 1888 the following Specifications and Tests for Cast-iron Wheels were adopted as standard. (See pages 151-154, report 1888.) In 1891 these were changed to Recommendations. (See pages 160, 161, report 1891.)

In 1908 these were modified and changed to standard and the form of contract omitted.

For 33-inch Cast-iron Wheels Having a Minimum Weight of 600, 650 and 700 Pounds. For Cars of 60,000. 80,000 and 100,000 Pounds Capacity.

1. Chills must have the same inside profile as shown by M. C. B. drawings of wheel tread adopted in 1906. The inside diameter of chill must be the M. C. B. standard of 33½ inches, measured at a point 2⅝ inches from outside of tread of wheel.

2. Wheels of the same normal diameter must not vary more than one-fourth (¼) of an inch above or below the mean size measured on

the circumference, and the same wheel must not vary more than one-sixteenth (1-16) of an inch in diameter. The body of the wheel must be smooth and free from slag, shrinkage or blowholes. The tread must be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in throat, and swollen rims.

3. The wheels must show clean gray iron in the plates, except at chaplets, where mottling to not more than one-half (½) inch from same will be permitted. The depth of pure white iron must not exceed one (1) inch nor be less than one-half (½) inch in the middle of the tread. It shall not exceed one (1) inch in the middle of the tread nor be less than three-eighths (⅜) inch in the throat, for wheels having a maximum weight of six hundred (600) pounds. It shall not exceed one (1) inch in the middle of the tread nor be less than seven-sixteenths (7-16) inch in the throat for wheels having a minimum weight of six hundred and fifty (650) pounds, and shall not exceed one (1) inch in the tread nor be less than one-half (½) inch in the throat for wheels having a minimum weight of seven hundred (700) pounds. The depth of white iron shall not vary more than one-fourth (¼) of an inch around the tread on the rail line in the same wheel.

4. When ready for inspection, the wheels must be arranged in groups, all wheels of the same date being grouped together, and for each hundred wheels which pass inspection and are ready for shipment, two representative wheels shall be taken at random, one of which shall be subjected to the following tests:

The wheels shall be placed flange downward on an anvil block, weighing not less than seventeen hundred (1,700) pounds), set on rubble masonry at least two (2) feet deep, and having three supports not more than five (5) inches wide to rest upon. It shall be struck centrally on the hub by a weight of two hundred (200) pounds. For wheels having a minimum weight of six hundred (600) pounds, ten (10) blows falling from a height of nine (9) feet. For wheels having a minimum weight of six hundred and fifty (650) pounds, twelve (12) blows falling from a height of ten (10) feet, and for wheels having a minimum weight of seven hundred (700) pounds, twelve (12) blows falling from a height of twelve (12) feet. Should the test wheel stand the given number of blows without breaking in two or more pieces, the inspector will then subject the other wheel to the following test:

The wheel must be laid flange down in the sand and a channel way one and one-half (1½) inches wide and four (4) inches deep must be molded with green sand around the wheel. The clean tread of the wheel must form one side of the channel way, and the clean flange must form as much of the bottom as its width will cover. The channel way must then be filled to the top with molten cast iron, which must be hot enough, when poured, so that the ring which is formed when metal is cold shall be solid or free from wrinkles or layers. The time when the pouring ceases must be noted, and two minutes later an examination of the wheel

must be made. If the wheel is found broken in pieces, or if any crack in the plate extends through or into the tread, the one hundred wheels represented by the tests will be rejected.

5. In case of the drop tests, should the test wheel break in two or more pieces with less than the required number of blows, then the second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test it shall be optional with the inspector whether he shall test the third wheel or not; if he does not do so, or if he does, and the third wheel stands the test, the hundred wheels shall be accepted as filling the requirements of the drop test.

6. The lower face of the weight of two hundred (200) pounds shall be eight (8) inches in diameter, and have a flat face.

7. The thickness of the flange shall be regulated by the maximum and minimum flange thickness gauges adopted by the M. C. B. Association in 1907.

8. All wheels must be numbered consecutively in accordance with instructions from the railroad company purchasing them, and shall have the number, the normal weight of the wheel, also the day, month and year when made plainly formed on the inside plate in casting, and no two wheels shall have the same number. All wheels shall also have the name of the maker and place of manufacture plainly formed on the outside plate in casting.

Wheels made to conform to these specifications should also be plainly marked M. C. B. 1907.

9. Individual wheels will not be accepted which

(1) Do not conform to standard design and measurements.

(2) Are under weight.

(3) Have physical defects described in Section 2.

Any lot of one hundred wheels submitted to test will not be accepted

(1) If wheels broken do not meet the prescribed drop test.

(2) If the wheel tested does not stand the thermal tests.

(3) If the conditions prescribed in Section 3 are not complied with.

10. All wheels must be taped with M. C. B. standard design of wheel circumference tape having numbers 1, 2, 3, 4, 5 stamped one-eighth (1/8) inch apart, the figure three (3) to represent the normal diameter, 103.67 inches circumference, the figure one (1) the smallest diameter and the figure five (5) the largest diameter.

FITTINGS FOR LUBRICATORS.

At the convention of 1906 the Committee on Locomotive Lubrication proposed a standard location of holding arm shoulder and oil and steam connection joint faces; also a system of fittings and joints for all connections. Fig. 1 shows the location for connection of joints and holding arm.

Figs. 2, 3, 4 and 5 show pipe joints and fittings, and Fig. 6 illustrates the holding arm proposed.

On reference to letter ballot they were adopted as standard. They are as shown herewith.

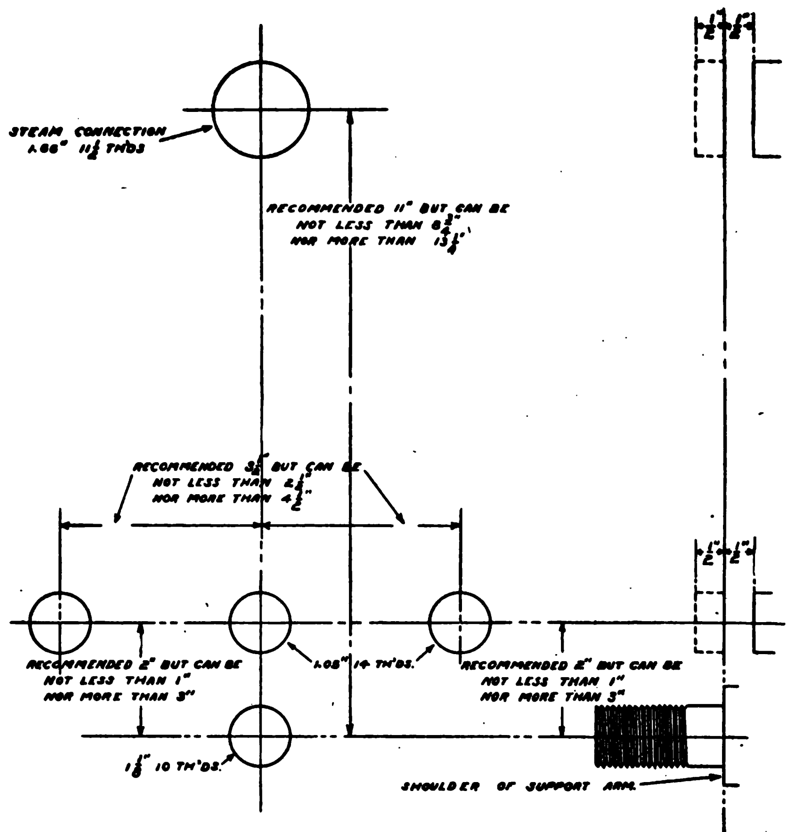


FIG. 1.

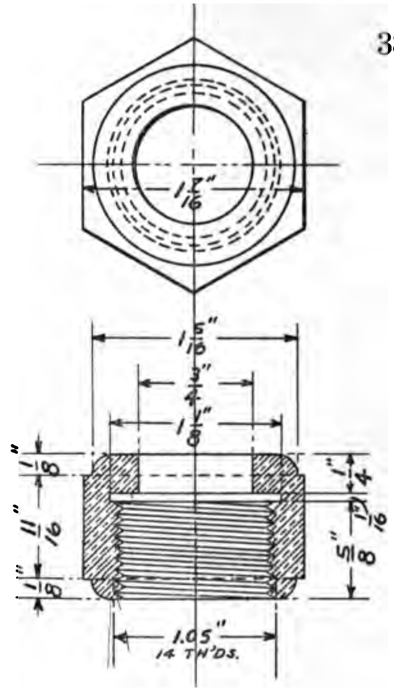


FIG. 2.

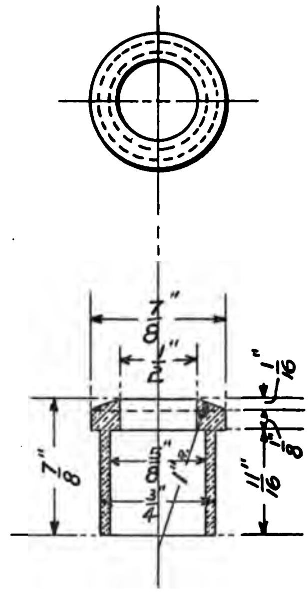


FIG. 3.

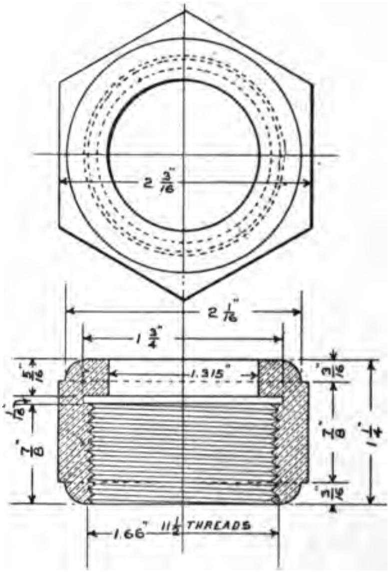


FIG 4

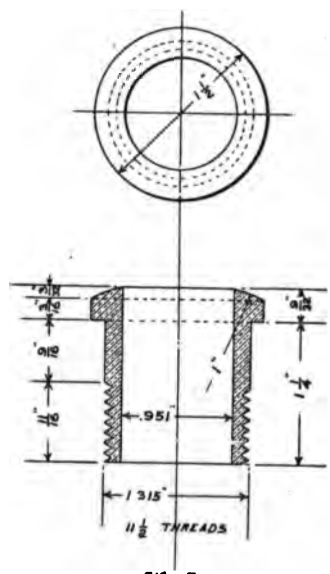


FIG 5.

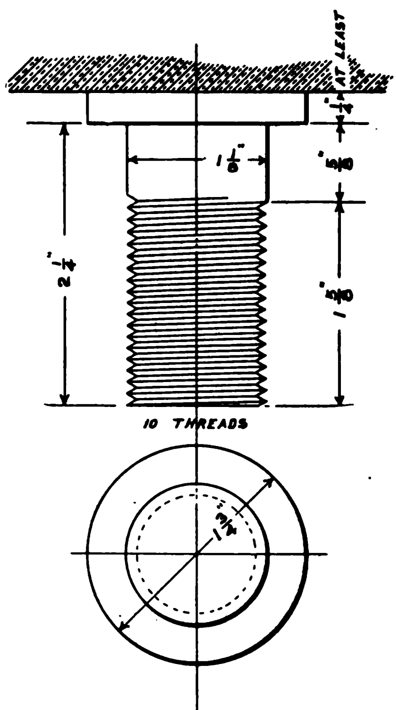


FIG. 6.

STANDARD METHOD OF CONDUCTING EFFICIENCY TESTS OF LOCOMOTIVES.

In 1894 a method of conducting tests of locomotives was submitted by a committee of the Association, and on motion adopted as a standard of the Association. (See page 200, report 1894.)

The tests are as follows:

*A. Preparations for Test and Location of Instruments.**

1. The locomotive should be put in good condition preparatory to the test. The boiler and tubes should be tight, and both the interior and exterior surfaces should be clean, and, if possible, free from scale. There should be no lost motion in the valve gear, and the valves should be set properly. No change in the engines should be allowed during the progress of a series of tests, unless so ordered for the purposes of the trial.

A glass water-gauge should be fitted to the boiler, if not already provided, and side of it there should be a graduated scale to assist in

* The directions here given apply largely to both shop and road tests, but especially he latter.

correcting water quantities, caused by change of inclination of the boiler, and difference of levels when beginning and ending a test. The notches on the quadrant should be marked by large figures, so that they can be read by the cab assistant. The throttle valve lever should be provided with a scale so as to show the degree of opening of the throttle valve.

The point of cut-off of the valves should be determined for each notch in the quadrant.†

2. The valves and pistons should be tested for leakage with the engine at rest. The steam valve can be tried by setting the engine so that the valve on one side will be at the center of its throw, in which position both ports are usually covered, and pulling open the throttle valve, blocking the drivers if there is a tendency for the engine to be set in motion. Leakage of the valve, if any occurs, will show itself by escaping at the open cylinder cocks. The tightness of the piston may be tested by setting the engine so that it makes steam, blocking the drivers and opening the throttle valve. This should be tried first on one cylinder and then on the other, and, if desired, it may be tried with the pistons at various points in the stroke. The leakage, if any occurs, will be shown at the open cylinder cock.

3. The following instruments should be verified or calibrated: Steam gauges, draft gauge, pyrometer, thermometers for calorimeter and feed-water, water meter, tank, revolution counter, indicator springs, dynamometer springs and dynamometer recording mechanism. The radiation loss on the steam calorimeter should be determined, or the normal readings ascertained, and the quantity of steam which passes through the instrument in a given time should be measured.

4. The quantities of steam used by the various auxiliaries of the locomotive can be determined by noting the change in weight of the engine standing upon scales while they are each in use under the usual conditions for known times. Similarly leakage of water and steam can be determined. The quantities can then be properly deducted from the total water used.

5. To facilitate the measurement of coal and the determination of the quantity used during any desired period of the run, it is desirable to provide a sufficient number of sacks of a size holding a weight of, say, 100 pounds, and weigh the coal into these sacks preparatory to starting on the test. If desired, the sacks may be numbered to facilitate the accuracy of record.

6. The instruments and other apparatus that should be provided and their locations are as follows:

To facilitate the work of operating the indicators and reading the instruments at the front end, the smoke-box should be surrounded with a wooden fence, or "pilot-box," as it may be called, resting on the top of the cow-catcher, and extending back far enough to inclose also the sides

† See appendix for description of valve diagram apparatus used on Norfolk & Western Railway.

of the cylinders. This box is floored over above the cylinder heads, and the inclosure thus provided forms a convenient place for the accommodation of the assistants at this end of the locomotive, and it affords them some measure of protection against wind and rain, as also the joltings and vibrations due to rapid travel.

A special steam-gauge with a long siphon is to be used for registering the boiler pressure. It can best be located on the left-hand side of the cab.

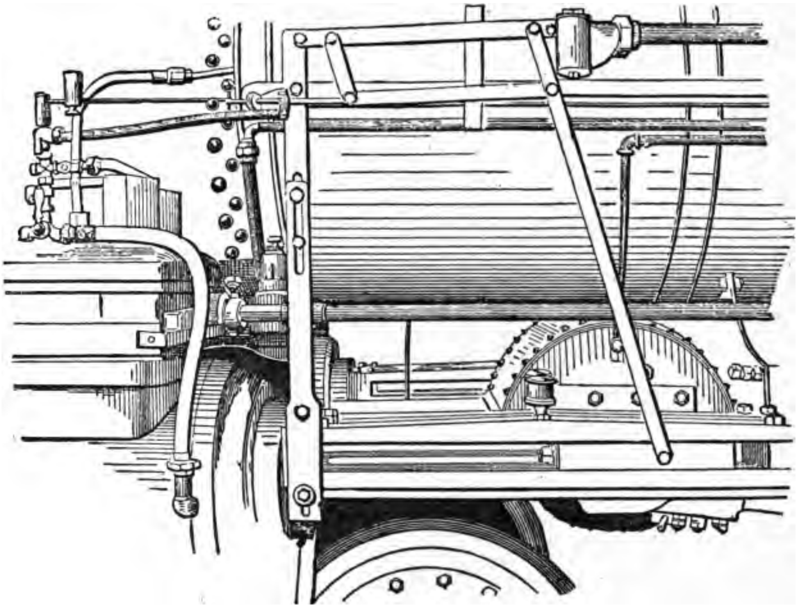
The indicator apparatus which is most suitable consists of a three-way cock for the attachment of the indicators, and some form of pantagraph or other correct reducing motion for the driving rig. The pipes leading from the cock to the cylinder should be ¾ inch diameter inside, and they should connect into the side of the cylinder rather than into the two heads. The indicator should also be piped so that a steam-chest diagram can be drawn by it, and from this the steam-chest pressure determined. Sharp bends in the pipe should be avoided, and they should be well covered, to intercept radiation. The three-way cock should be provided with a clamp rigidly secured to the cylinder, and thus overcome any tendency of the indicators to move longitudinally with reference to the driving rig. Absolute rigidity is highly essential in this particular. Two forms of pantagraph motion are shown in Figs. 1 and 2. In both of these the reduced motion is transmitted to the indicator through a light rod, working horizontally. By this means a cord eight or ten inches in length is sufficient for connection to the indicator. Care should be taken to set the instrument in such a position that the cord pin in the end of the rod travels in a direction pointing to the groove in the paper drum. Pantagraph motions arranged as noted are preferable to the common pendulum and quadrant reducing mechanism, with its long stretch of cord. For another type of correct reducing motion see appendix.

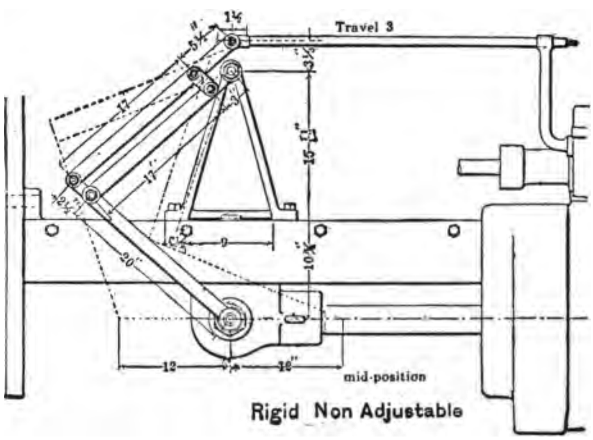
A draught gauge consisting of a U tube containing water, properly graduated in inches, should be placed in the cab and connected to the smoke-box by a ⅜-inch pipe. This long pipe steadies the water, and the readings can be taken by the cab assistant.

A pyrometer for showing the temperature of the escaping gases should be used in a position below the tip of the exhaust nozzles.

The calorimeter should be attached either to the steam dome at a point close to the throttle opening or to the steam passages in the saddle casting on one side, according as it is desired to obtain the character of the steam at one point or the other. The former location is preferred by the committee. A perforated ½-inch pipe should be used for sampling and conveying the steam to the calorimeter pipe. For descriptions of various forms of calorimeters which are adapted to locomotive use, see Trans. A. S. M. E., Vol. X, page 327; Vol. XI, page 790; Vol. XII, page 825.

The water meter should be attached to the suction pipe of the injector, and located at a point where it can be conveniently read when the locomotive is running. It should be provided with a check valve to





Rigid Non Adjustable

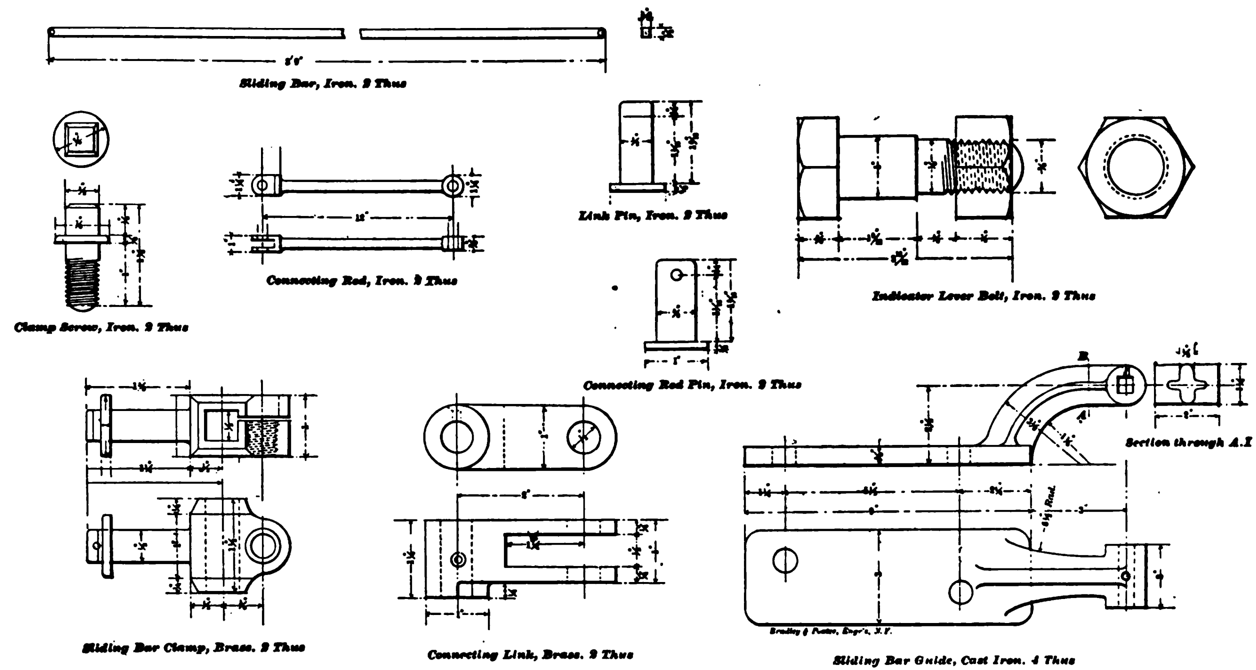
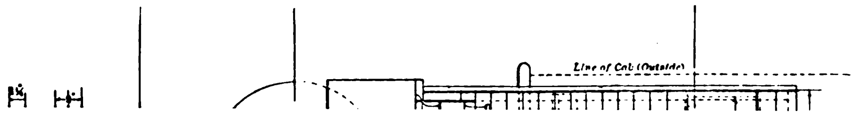

Sliding Bar, Iron. 2 Thus
Clamp Screw, Iron. 2 Thus
Connecting Rod, Iron. 2 Thus
Link Pin, Iron. 2 Thus
Connecting Rod Pin, Iron. 2 Thus
Indicator Lever Bolt, Iron. 2 Thus
Section through A.I
Sliding Bar Clamp, Brass. 2 Thus
Connecting Link, Brass. 2 Thus
Sliding Bar Guide, Cast Iron. 4 Thus

FIGURE 2.


Line of Cab (Outside)

The cab assistant notes the time of leaving and arriving at stations, the position and time of opening and closing the throttle, the time of taking indicator diagrams, for which he shall determine the time and give the signal by any effective means; the time of blowing off, the time the blower is applied, the number of applications of the injector, the position of the reverse lever, the steam pressure, the draught gauge, the time of passing important stations, the readings of the water glass, meter and air-pump counter, the number of sacks of coal used, the reading of the tank float, the temperature of the feed-water and atmosphere, the direction and force of the wind, the condition of the rail and state of the weather. Many of these readings are as nearly as possible simultaneous with the signal for taking indicator diagrams, and one experienced man in the cab will have no difficulty in entering all of these records in a note-book properly prepared with ruled columns and headings. In case of short stops at stations, one of the men at the indicators can take the tank float observations, or any observation that is advisable at stations. The weights of coal placed upon the tender have been checked by these two persons when weighing it out to the engine. One man takes the level of the boiler at stopping-places where this is required.

When the calorimeter and smoke-box gas samples are used another assistant is required.

In the dynamometer car two (2) men are required, who record the time of each start and stop, the time of passing each station and mile-post, time of taking each indicator diagram as obtained from the signal given by the cab assistant, and all these events are marked on the dynamometer paper. These men, as well as one of the engine assistants, will note the direction and force of the wind, the temperature of the atmosphere and condition of the weather.

8. It is of great importance, after the preparatory work has been accomplished, that a preliminary run be made with the locomotive, in order to fairly test the apparatus and to accustom the men to their duties.

B. The Dynamometer Car.

With a suitable dynamometer car the force required to move the train, or the pull upon the drawbar, is registered upon a strip of paper traveling at a definite rate per mile. The scale upon which this diagram is drawn should be as large as is possible within reasonable limits. A scale of ¼ inch per 1,000 pounds pull is suitable, as the maximum registered pull rarely exceeds 30,000 pounds.

The height of the diagram should be measured from a base line drawn upon the paper by a stationary pen, so located that when no force is exerted upon the drawbar the base line should coincide with zero pull.

The apparatus should be arranged to make a record of time marks in connection with the curve showing the pull. A chronometer should be provided having an electric circuit-breaker, by means of which a mark is made on the dynamometer paper every five (5) seconds. A better appa-

ratus may be used in which a continuous speed curve is traced upon the paper parallel to the curve of pull. The ordinates of this curve, measured from a base line, give the speeds desired.

The location of mile-posts and other points along the route should be fixed upon the dynamometer paper by employing an additional pen, and operating it by means of electric press buttons, which are placed at convenient points in the car.

As already noted, a similar device should be provided for marking upon the dynamometer paper the time of taking indicator diagrams.

The rate of travel of the paper per mile should be such that one inch measured upon the diagrams represents 100 feet for short-distance work, and for long-distance work ½ inch to ¼ inch should be used to represent 100 feet of track. The driving mechanism for the paper should be so arranged that it can be changed to give these three proportions. It is necessary to have all the registering pens located upon the same transverse line at a right angle with the direction of the movement of the paper in order that simultaneous data may be recorded.

C. Method of Conducting the Road Test.

The locomotive having been brought to the train, the steam pressure being at or near the working point, the fire being clean and in good condition, the ash-pan being also clean, observations are taken, say, five (5) minutes before starting time, of the thickness and condition of the fire, the height of water in the boiler, the depth in the tank, the levels, the water meter and the air-pump counter, and thereafter the regular observations are carried forward, and coal is fired from the weighed sacks.

Indicator diagrams should be taken as frequently as possible, the intervals between them being not over two minutes.

Other regular observations should be taken at close intervals. Calorimeter readings, when taken, should be continued for at least five (5) minutes at one minute intervals.

At water stations careful records should be obtained of water heights and levels of boiler and tank.

As the end of the route is approached, the fire should be burned down so as to leave the same amount and the same condition as at the start. When the end is finally reached the fire should be raked and its condition carefully noted. If it differs from that which obtained at the beginning, an estimated allowance must be made for such difference.

At the close of the test the height of water in the boiler should be the same as at the beginning, or, if not, the difference, corrected for inclination of the boiler, should be allowed for.

During the process of weighing the coal into the sacks numerous samples should be obtained and placed in a covered box, and a final sample of these selected. This is to be dried and subjected to chemical analysis and calorimeter test. The sample is weighed before and after drying, and data obtained for determining the weight of dry coal used dur-

ing the test. The temperature of the feed-water can be best taken at the tank cock, in order to obtain that of a mixed sample.

The duration of the road test is the length of time which the throttle valve is open.

D. The Data and Results.

The data and results of the road test may be tabulated in the form given in Table No. 1. This form corresponds in general with that recommended for shop test, namely, Table No. 2.

TABLE No. 1.

Data and Results of Road Test on....Engine, Made....189 .

General dimensions, etc. (to be accompanied by a complete description of engine with drawings and dimensions, also of train and route):

1. Kind of engine ....
2. Size of cylinders..
3. Clearance of cylinders ....per cent
4. Area of heating surface ....sq. ft.
5. Area of grate surface..sq. ft.
6. Size of exhaust nozzles ....inches
7. Average weight of locomotive and tender (including water)....tons
8. Number of cars ....
9. Weight of cars ....tons
10. Length of route ....miles
11. Number of ton-miles of train load ....ton-miles
12. Number of ton-miles of total load..........................ton-miles
13. Schedule time of trips..

Total Quantities.

14. Duration or time throttle valve is open ....hours
15. Weight of dry coal burned ....lbs.
16. Weight of water evaporated, corrected for moisture in the steam and loss at injector*..................................lbs.
17. Weight of ashes and refuse taken from ash-pan...................lbs.
18. Weight of cinders from smoke-box ....lbs.
19. Percentage of ash as found by coal calorimeter test..........per cent
20. Total heat of combustion as found by calorimeter test ....B. T. U.
21. Results of chemical analysis of coal ....

Power Data.

22. Mean effective pressure, H. P. cyls..............................lbs.
23. Mean effective pressure, L. P. cyls..............................lbs.
24. Average revolutions per minute....................................rev.
25. Indicated horse-power, H. P. cyls...............................H. P.

* Should be corrected for steam used by calorimeter, air-pump, blower, safety valve and whistle, to find cylinder results—line 56.

26. Indicated horse-power, L. P. cyls............................H. P.
27. Indicated horse-power, whole engine.........................H. P.
28. Pull on drawbar...lbs.
29. Dynamometer horse-power ....H. P.

Averages of Observations of Instruments.

30. Average boiler pressure ....lbs.
31. Average steam-chest pressure ....lbs.
32. Average temperature of smoke-box.............................. °
33. Average drought suction... "
34. Average temperature of feed-water............................ °
35. Average temperature of atmosphere............................ °
36. Average percentage of moisture in the steam.................per cent
37. Maximum percentage of moisture in the steam..............per cent
38. Weather, wind, etc..

Other Data.

39. Average position of throttle.......................................
40. Average position of reversing lever...............................
41. Average speed in miles per hour..................................
42. Maximum speed in miles per hour.................................
43. Number of stops...
44. Average number of strokes of air pump per minute................
45. Total estimated weight of steam used by air pump per hour......lbs.
46. Estimated loss of steam at safety valve per hour.................lbs.
47. Estimated loss of steam at whistle per hour.....................lbs.
48. Estimated weight of steam used by blower per hour..............lbs.
49. Estimated loss of steam at calorimeter per hour.................lbs.

Hourly Quantities.

50. Weight of dry coal burned per hour.............................lbs.
51. Weight of dry coal burned per hour per square foot of grate surface ....lbs.
52. Weight of coal burned per square foot of heating surface........lbs.
53. Weight of water evaporated per hour............................lbs.
54. Equivalent weight of water evaporated per hour with feed-water at 100° and pressure 70 lbs...........................lbs.
55. Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface.........................lbs.
56. Weight of water consumed by engine cylinder (line 53, less sum of lines 45, 46, 47, 48 and 49)..........................lbs.

Principal Results — Complete Engine and Boiler.

57. Coal consumed per I. H. P. per hour.............................lbs.
58. Coal consumed per dynamometer horse-power per hour..........lbs.
59. Coal consumed per ton-mile of train load........................lbs.

60. Coal consumed per ton-mile of total load........................lbs.
61. Weight of standard coal consumed per I. H. P. per hour.........lbs.
62. Weight of standard coal consumed per dynamometer horse-power per hour...lbs.
63. Weight of standard coal consumed per ton-mile of train load....lbs.
64. Weight of standard coal consumed per ton-mile of total load.....lbs.

Boiler Results.

65. Water evaporated per pound of coal ....lbs.
66. Equivalent evaporation per pound of coal from and at 212°......lbs.
67. Equivalent evaporation per pound of combustible from and at 212° ....lbs.
68. Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units...

Cylinder Data.

69. Mean initial pressure above atmosphere..........................lbs.

		H. P. Cyl.	L. P. Cyl.
70.	Cut-off pressure above zero...............lbs.	......	......
71.	Release pressure above zero ....lbs.	......	......
72.	Compression pressure above zero..........lbs.	......	......
73.	Lowest back pressure above or below atmosphere ....lbs.	......	......
74.	Proportion of forward stroke completed at cut-off	......	......
75.	Proportion of forward stroke completed at release	......	......
76.	Proportion of return stroke uncompleted at compression	......	......
77.	Mean effective pressure (lines 22 and 23) lbs.	......	......

Cylinder Results.

78. Total water consumed per indicated horse-power per hour, corrected for moisture in steam.............................lbs.
79. Water consumed per I. H. P. per hour by cylinders alone (from line 56)...lbs.

		H. P. Cyl.	L. P. Cyl.
80.	Steam accounted for by indicators at cut-off.lbs.	......	......
81.	Steam accounted for by indicator at release.lbs.	......	......
82.	Proportion of feed-water used by cylinders (line 79) accounted for at cut-off............	......	......
83.	Proportion of feed-water used by cylinders accounted for at release..................	......	......
84.	Total heat supplied by boiler to cylinders per hour in British thermal units............	......	......

	H. P. Cyl.	L. P. Cyl.
85. Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units....................	......	......
86. Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units	......	......

The following form for the tabulation of the results of locomotive tests will be found convenient. They can, of course, be modified to suit any method of testing, whether standard or not:

LOCOMOTIVE TESTS — GENERAL RESULTS.

..................................*Railroad Co.*
................*Tests of Locomotive No*......, *between*................
and...........................*Distance*......*Miles. Train No*........
................*Bound.* ...., *18*....
Kind of Coal............................ *Coal Analysis*..............
Calorimetric Value of Coal...

Trip No...
Date ....
Left ....at..
Arrived ....at..
Left ....at..
Arrived ....at..

1. Weather ....
2. Mean temperature of atmosphere.......................................
3. Direction of wind...
4. Velocity of wind, miles per hour......................................
5. Condition of rails..
6. Weight of train in tons of 2,000 lbs., including locomotive, tender, passengers and freight.......................................
7. Weight of train in tons of 2,000 lbs., excluding the locomotive and tender ....
8. Equivalent number of standard cars at ....tons each.........
9. Size of exhaust nozzle, single or double.............................
10. Maximum boiler pressure by gauge.....................................
11. Minimum " " " " ....
12. Average " " " " ....
13. Prevailing position of throttle (wide open = 1.00)...................
14. " " " reverse lever (notch) ....
15. " points of cut-off ....
16. Schedule time in motion..
17. Actual " " " ....
18. Time made up in minutes..

19. Aggregate intermediate stops, minutes....................
20. Time during which power was developed, or throttle open..........
21. Maximum number of revolutions per minute....................
22. Minimum number of seconds per mile....................
23. Maximum rate of speed, miles per hour....................
24. Average speed, miles per hour....................
25. Actual weight of coal fired....................
26. Moisture in coal, percentage....................
27. Dry coal fired....................
28. Actual weight of wood used....................
29. Total weight of coal fired (wood added at .4)....................
30. Weight of refuse in fire-box and ash-pan....................
31. " unconsumed coal recovered from fire-box and ash-pan.......
32. Total weight of coal consumed (Item 29-31)....................
33. Net weight of ashes in fire-box and ash-pan....................
34. Weight of cinders (sparks) in smoke-box....................
35. Percentage of ash in coal....................
36. " " cinders (sparks)....................
37. " " total refuse....................
38. Percentage of combustible consumed....................
39. Weight of combustible utilized....................
40. Number of miles run per ton (2,000 lbs.) of coal....................
41. " " pounds of coal used per mile....................
42. Coal used per ton of train per 100 miles....................
43. " " " car-mile....................
44. Average weight of coal burned per square foot of grate surface per hour....................
45. Total coal per indicated horse-power developed per hour............
46. Average temperature of feed-water....................
47. Weight of water drawn from tender....................
48. Waste of injector, leakage, etc....................
49. Weight of water apparently evaporated (Item 47-48)................
50. Percentage of moisture in steam....................
51. Water actually evaporated, corrected for quality of steam............
52. Actual evaporation per pound of total coal....................
53. Equivalent evaporation from and at 212° per pound of coal........
54. " " " " " " " " " combustible.
55. Water used per ton of train per 100 miles....................
56. " " " car-mile....................
57. " " " hour while developing power....................
58. " " " indicated horse-power per hour....................
59. " " " sq. ft. of heating surface, from and at 212°..........
60. " " " " " " grate " " " " ....
61. Maximum indicated horse-power developed....................
62. Average " " " ....
63. Dry steam used per indicated horse-power, per hour, per indicator diagram ....

64. Average number of sq. ft. of heating surface per indicated horse-power
65. Average number of indicated horse-power per sq. ft. of grate surface.
66. Prevailing temperature in smoke-box while using steam............
67. " draft in smoke-box while using steam, in inches of water.

SHOP TEST.

A. Preparation and Location of Instruments.

In preparing for a shop test the preparations described for the road test should be followed so far as the nature of the test requires. When run as a stationary engine the locomotive is not circumscribed by the conditions of road service, and many provisions required on the road are unnecessary. It is unnecessary to determine the quantity of steam consumed by the air pump and auxiliaries, for these are not brought into use on the shop test; and no occasion exists for finding the quantity lost at the safety valve, for on the continuous shop run the steam pressure can be maintained at a uniform point, and blowing off readily prevented. It is unnecessary to use sacks for the convenient measure of coal, because the coal can be readily weighed up in lots as fast as needed for the test. It is unnecessary to provide a "pilot-box," and no fixed location of the instruments is required, as on the road test. The feed-water may be weighed before it is supplied to the tank, and the tank may be used in this case as a reservoir, the float showing its depth. The meter would thus be unnecessary as the principal instrument of measurement, but a meter is in all cases useful as a check upon this most important element in the data. The long indicator pipes required on the road test may be dispensed with, and one indicator applied close to each end of the cylinder, a practice much to be preferred to the use of a three-way cock and the single indicator. The dynamometer car is not required, but its equivalent should be provided, consisting of a dynamometer which registers the pull on the drawbar in the same manner as the device used on the road.

The number of assistants required on a shop test is less than that needed for a road test. A good test can be made with four (4) assistants, distributed as follows:

One assistant for operating indicators.

One assistant for measuring water.

Two (2) assistants for general observations and coal measurement.

B. Conditions of Test.

The test should be continued for a run of at least two (2) hours from the time normal conditions have been established.

At the close of the test the water height in the boiler and the height of water in the tank should be the same as at the beginning, or proper corrections made for any differences which may exist.

The fire-box and ash-pit are then cleaned, and such unburnt coal as may be contained in the refuse is separated, weighed and deducted from

the total weight of coal fired. The balance of the refuse is weighed, as also the cinders removed from the smoke-box.

During the progress of the test samples of the various charges of coal should be obtained, and at its close a final sample of these should be selected, dried and subjected to chemical analysis and calorimeter test. The weight of the sample as taken before and after drying to ascertain the weight of moisture contained in the fuel.

C. The Data and Results.

The data and results of the shop test can best be arranged in the manner indicated in Table No. 2. So far as these are in common with the data and results obtained on the road test, the forms used on both kinds of test are identical.

TABLE No. 2.

Data and Results of Shop Test on....Engine, made......189......

General dimensions, etc. (to be accompanied by a complete description, with drawings and full dimensions).

1. Kind of engine..
2. Size and clearance of cylinders......................................
3. Area of heating surface..
4. Area of grate surface..
5. Diameter of exhaust nozzles..

	Total Quantities.		Whole Run.
6.	Duration	hrs.	......
7.	Weight of dry coal burned, including .4 weight of wood.	lbs.	......
8.	Weight of water evaporated corrected for moisture in the steam	lbs.	......
9.	Weight of ashes and refuse from ash-pan..............	lbs.	......
10.	Weight of cinders from smoke-box..................	lbs.	......
11.	Percentage of ash as found by calorimeter test....	per cent	......
12.	Total heat of combustion per lb. coal as found by calorimeter test..................................	B. T. U.	......
	Power Data.		
13.	Mean effective pressure, high-pressure cylinders......	lbs.	......
14.	Mean effective pressure, low-pressure cylinders........	lbs.	......
15.	Average revolutions per minute......................	rev.	......
16.	Indicated horse-power, high-pressure cylinders.....	H. P.	......
17.	Indicated horse-power, low-pressure cylinders.......	H. P.	......
18.	Indicated horse-power, total.........................	H. P.	......
19.	Pull on drawbar	lbs.	......
20.	Dynamometer horse-power	H. P.	......
	Averages of Observations.		
21.	Average boiler pressure.............................	lbs.	......
22.	Average steam-chest pressure.......................	lbs.	......

		Whole Run.
23.	Average temperature of smoke-box....................°	......
24.	Average draught suction............................"	......
25.	Average temperature of feed-water ....°	......
26.	Average temperature of atmosphere....................°	......
27.	Average percentage of moisture in the steam....per cent	......
28.	Maximum percentage of moisture in the steam...per cent	......

Hourly Quantities.

29.	Weight of dry coal burned per hour.................lbs.	......
30.	Weight of dry coal burned per hour per square foot of grate surface.................................lbs.	......
31.	Weight of coal burned per hour per square foot of heating surface................................lbs.	......
32.	Weight of water evaporated per hour...............lbs.	......
33.	Equivalent weight of water evaporated per hour with feed-water at 100° and pressure at 70 lbs..........lbs.	......
34.	Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface.........lbs.	......

Principal Results, Complete Engine and Boiler.

35.	Coal consumed per I. H. P. per hour.................lbs.	......
36.	Coal consumed per dynamometer horse-power per hour ....lbs.	......
37.	Weight of "standard coal" consumed per I. H. P. per hour ....lbs.	......
38.	Weight of "standard coal" consumed for a dynamometer horse-power per hour....................lbs.	......

Boiler Results.

39.	Water evaporated per pound of coal..................lbs.	......
40.	Equivalent evaporation per pound of coal from and at 212°.............. ....lbs.	......
41.	Equivalent evaporation per pound of combustible from and at 212°..............................lbs.	......
42.	Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units....................	......

Cylinder Data.

43.	Mean initial pressure above atmosphere.............lbs.		......
		H. P. Cyl.	L. P. Cyl.
44.	Cut-off pressure above zero.................lbs.	......	......
45.	Release pressure above zero................lbs.	......	......
46.	Compression pressure above zero...........lbs.	......	......

	H. P. Cyl.	L. P. Cyl.
47. Lowest back pressure above or below atmosphere ....lbs.	......	......
48. Proportion of forward stroke completed at cut-off	......	......
49. Proportion of forward stroke completed at release	......	......
50. Proportion of return stroke uncompleted at compression	......	......

Cylinder Results.

51. Total water consumed per indicated horse-power per hour corrected for moisture in steam....lbs.

52. Water consumed per I. H. P. per hour by cylinders alone (from line 51 less all measured losses)....lbs.

	H. P. Cyl.	L. P. Cyl.
53. Steam accounted for by indicators at cut-off.lbs.	......	......
54. Steam accounted for by indicators at release.lbs.	......	......
55. Proportion of feed-water used by cylinders (line 52) accounted for at cut-off.........lbs.	......	......
56. Proportion of feed-water used by cylinders accounted for at release ....lbs.	......	......
57. Total heat supplied by boiler to cylinders per hour in British thermal units....	......	......
58. Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units....	......	......
59. Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units....	......	......

Reports should give a copy of a set of sample indicator diagrams, also combined diagram (in case of compound engines) and a chart showing graphically the principal data.

SUPPLEMENT.

Description of Norfolk & Western Indicator Rigging. Fig. 1, General Arrangement. Fig. 2, Details.

This form of indicator rigging involves the use of a lever (supported from the running-board by a suitable bracket), and connected at its lower end to the cross-head (by a link 12 in. long). The indicator drum cord takes its motion from a square bar working in suitable guides and connected by a short link to the main lever. In order to secure a perfectly parallel motion, the length of the cross-head link should bear the same ratio to the length of the indicator-bar link as the full length of the main lever bears to the distance from fulcrum of main lever to point of connection of the indicator-bar link. For an engine with 24-inch stroke this ratio should be 1 to 6, in order to produce an indicator card 4 inches

long, and the long and short links should be 12 inches and 2 inches, respectively.

Description of Valve Motion Indicator. Fig. 3.

In this apparatus a string is wound around the groove on one end of drum, and passed over proper pulleys until it leads off in a line with the motion of the cross-head, and the other end is attached to the cross-head, so that any motion of the piston is communicated by the cord to the drum, causing corresponding rotation.

A cord from the pen-bar is led over suitable pulleys and attached to valve rod in the same manner. The combination of the two motions, as will be seen, will give an elliptical diagram in which the abscissæ represent the position of the piston, and the ordinates the position of the valve.

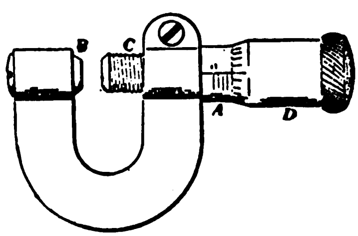
Description of Boiler Lever Indicator. Fig. 4.

This apparatus consists of a spirit level mounted in a saddle which slides on an arc of a large circle. This arc is graduated, and should be sufficiently curved to operate on the heaviest grade upon which the engine will be tested.

By putting the engine on jacks or cranes, and giving different elevations to the boiler, the height of water may be measured by means of a meter to certain points on the gauge-glass, and a corresponding table made, which will denote the quantity of water in the boiler for each different angular position of the boiler. These figures can be used to make corrections on the meter readings, allowing for inclinations of the track on which the engine is standing by simply pushing the spirit lever to a horizontal position and noting the reading on the indicator.

SHEET METAL GAUGE.

At the convention of 1882 the Brown & Sharpe micrometer gauge shown below was adopted as standard for the measurement of sheet metal (see page 132, report 1882). Reaffirmed 1891 (see pages 160, 161, report 1891).



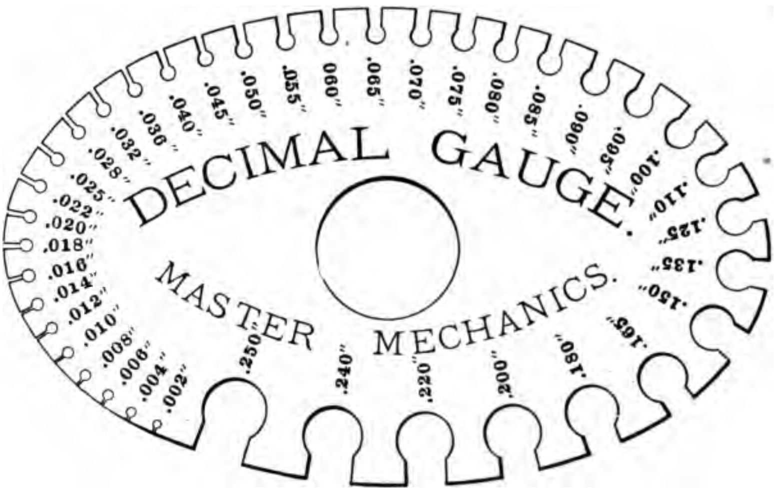
DECIMAL GAUGE.

At the convention of 1895 the following was adopted as a standard Decimal Gauge:

1st. The micrometer caliper should be used for laboratory and tool-room work, and in the shop when specially desired.

2d. The solid notch gauge should be used for general shop purposes.

3d. The form of this gauge shall be an ellipse whose major axis is 4 inches, the minor axis 2.5 inches, and the thickness .1 inch, with a central hole .75 inch in diameter.



4th. The notches in this gauge shall be as follows:

.002″	.022″	.060″	.110″
.004″	.025″	.065″	.125″
.006″	.028″	.070″	.135″
.008″	.032″	.075″	.150″
.010″	.036″	.080″	.165″
.012″	.040″	.085″	.180″
.014″	.045″	.090″	.200″
.016″	.050″	.095″	.220″
.018″	.055″	.100″	.240″
.020″	.....	.....	.250″

5th. All notches to be marked as in the above list.

6th. The gauge must be plainly stamped with the words "Decimal Gauge" in capital letters .2 inch high, and below this the words "Master Mechanics."

7th. In ordering material, the term gauge shall *not* be used, but the thickness ordered by writing the decimal as in above list. For sizes over ¼ inch, the ordinary common fractions may be used.

STANDARD DIMENSIONS AND THREADS OF WROUGHT PIPE.

At the convention of 1899, what is known as the Briggs Standard, as determined by the Pratt & Whitney gauges, of threads for wrought-iron pipe and couplings, was adopted as a standard of the Association.

The gauges used by the Pratt & Whitney Company were made by them from an autograph copy of a table made by Mr. Robert Briggs personally, who originally established and published these standard threads.

In 1908 these dimensions were revised and 11-inch and 12-inch pipe included. The words "wrought pipe" in the above heading includes wrought iron and steel pipe.

Diameter of Tube.			Thickness of metal.	Screwed Ends.	
Nominal inside.	Actual inside.	Actual outside.		Number of threads per inch.	Length of perfect screw.
Inches.	Inches.	Inches.	Inch	No.	Inch.
⅛	.269	0.405	0.068	27	0.19
¼	.364	0.540	0.088	18	0.29
⅜	.493	0.675	0.091	18	0.30
½	.622	0.840	0.109	14	0.39
¾	.824	1.050	0.113	14	0.40
1	1.047	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.467	2.875	0.204	8	0.89
3	3.066	3.500	0.217	8	0.95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.981	8.625	0.322	8	1.46
9	8.937	9.625	0.364	8	1.57
10	10.018	10.750	0.366	8	1.68
11	11.000	11.750	0.375	8	1.79
12	12.000	12.750	0.375	8	1.90

Tapers of conical tube ends, 1 in 32 to axis of tube. (¾-inch per foot.)

By the late action of the Manufacturers of Wrought-Iron Pipe, 9-inch outside diameter has been excepted from the original list, as above noted, the diameter now adopted being 9.625 instead of 9.688 inches given in the Briggs table.

STANDARD PIPE UNIONS.

At the convention of 1902 standard dimensions for pipe unions ⅛ to 4 inches, inclusive, were proposed for adoption, and, at the convention of 1903, the same were adopted as standard. These dimensions are shown on Table A.

AXLES FOR LOCOMOTIVE TENDERS.

At the convention of 1879 the Master Car Builders' Standard Axle with 3¾ by 7 inch journals was adopted as standard. (See pages 14-35, 52-58, report 1879.) Changed to Recommendations 1891. (See pages

is laid on the axles the reinforced parts will rest on the collars of the axle, and the balance of the straight-edge not touch the axle at any place. Next place the axle in position for test, lay the straight-edge on it, and measure the distance from the straight-edge to the axle at the middle point of the latter. Then, after the first blow, place the straight-edge on the now bent axle in the same manner as before, and measure the distance from it to that side of the axle next to the straight-edge at the point farthest away from the latter. The difference of the two measurements is the deflection.

SPECIFICATIONS FOR STEEL AXLES.

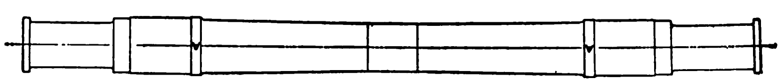
1. Axles will be ordered not less than 100 on one order. All axles must be made and finished in a workmanlike manner, and must be free from cracks, or seams, or flaws which can be detected by the eye. All parts must be rough turned, except at point "A" on diagram below.

2. All axles must be made of steel, and the material desired have the following composition:

Carbon ....0.40 per cent.
Manganese, not above ....0.50 per cent.
Silicon ....0.05 per cent.
Phosphorus, not above ....0.05 per cent.
Sulphur, not above ....0.04 per cent.

3. All axles must conform in sizes, shapes and limiting weights to the requirements given on the order or print sent with it. The rough turning must be done with a tool so shaped as to leave the surface free from ridges; and in centering them 60-degree centers must be used with proper clearance for lathe centers. All axles must be legibly stamped when offered for test, on the unfinished portion, "A" on diagram below, with the blow or heat number and the date, and on the cylindrical portion at center they must be stamped with the name of the maker.

Portions marked "A" to be unfinished and to have stamped upon either of them below number and date.



4. Manufacturers must notify..................................... when they are ready to ship not less than 100 axles; must have all the axles made from each heat, and no others, in a pile by themselves; must furnish the testing machine referred to in Section 6, and the proper appliances for checking the dimensions and weights; must have a car or cars ready to receive shipment; must furnish the labor and power neces-

sary to enable the inspector to promtply inspect and test; and ship or store the axles when tests are finished. Axles which, when offered for test, are so rusty as to hide defects will not be considered.

5. A shipment of axles being ready for test, the inspector will first make a list of the heat numbers in the various piles of axles offered, and the number of axles bearing the same heat number in each pile. If he finds in any pile axles bearing different heat numbers he must, before going further, have the pile rearranged, so that only those axles having the same heat number will be in the same pile. Also, if he finds in any pile any axles having evidence of changed or defaced heat numbers, or any axles having heat numbers not clearly legible, or any bearing heat numbers previously rejected, he will exclude such axles from further consideration. He will then examine the axles in each pile or heat, as to workmanship and defects visible to the eye, and as to whether they conform to dimensions and directions on the order, or tracing, or in these specifications. All axles not satisfactory in these respects must be laid aside and will not be further considered. This being done, if less than thirty axles in any heat are left, he will refuse to consider that heat further. If in this inspection defects are found which the manufacturer can remedy while the inspector is at the works, he may allow such defects to be cured and may count the axles which are successfully treated in this way as a part of the thirty above mentioned. Not less than thirty axles from any one heat having passed the foregoing inspection, the inspector will select from each pile or heat, one axle at random, and subject it to the physical test prescribed for such axles as may be under consideration. If the test axle fails to fill the physical requirements, all the axles from that heat of steel will be regarded as rejected, and none of them will at any time be considered again. If the test axle passes physical test, the inspector will draw a straight line parallel with the axis of this test axle ten (10) inches long, starting from one end of it, and prick-punch this line at several points. He will then have a piece about six (6) inches long cut off from the same axle, so as to leave some of the prick-punch marks on each piece of the axle. The 6-inch piece must be sent at once, properly tagged, to...................... The piles of axles which have passed physical test will be allowed to remain as the inspector leaves them, until the results of the chemical test are known. The 6-inch piece being received at the laboratory, a line will be drawn from the prick-punch line above described, through the center of the axle across the cut-off end, and a prick-punch mark made on this last line, 40 per cent of the distance from the center to the circumference of the axle. Borings for analysis will be taken by means of a ⅝-inch diameter drill, acting parallel to the axis of the axle, and starting with its center in the last described prick-punch mark. The borings will be analyzed in accordance with standard methods, and the results of analysis will be communicated to the inspector, who will at once proceed to the works, and reject, or accept and ship, or mark and store, as the case may be, and axles in question.

If the analysis of any test axle shows that the steel does not meet the chemical requirements, all of the axles of that heat will be regarded as rejected, and none of them will at any time be considered again. If the analysis of any test axle shows that the steel meets the chemical requirements, all of the axles of that heat which have passed inspection and physical test will be regarded as accepted. The inspector will proceed to load and ship from the accepted axles as many as may be required to fill the order. If, as the result of inspection and the physical and chemical tests, more axles are accepted than the order calls for, such accepted axles in excess will be stamped by the inspector with his own name, and will then be piled and allowed to remain at the works, subject to further orders from the purchasing agent. On receipt of further orders, axles once accepted will, of course, not be subject to further test, but in no case will even accepted axles be loaded and shipped except in the presence of the inspector. In all cases the inspector will keep an accurate record of the heat numbers, of the number of axles in each heat which are rejected, or stored, and will transmit this information with each report.

6. All axles will be tested physically by drop test. The testing machine must conform in its essential parts to the drawings adopted by the Master Car Builders' Association. These essential parts are: The points of supports on which the axle rests during tests must be three feet apart from center to center; the tup must weigh 1,640 pounds; the anvil, which is supported on springs, must weigh 17,500 pounds; it must be free to move in a vertical direction; the springs upon which it rests must be twelve in number, of the kind described on drawing; and the radius of supports and of the striking face on the tup in the direction of the axis of the axle must be five (5) inches. When an axle is tested it must be so placed in the machine that the tup will strike it midway between the ends, and it must be turned over after the first and third blows, and when required, after the fifth blow. After the first blow, the deflection of the axle under test will be measured in the manner specified below.

7. It is desired that the axles, when tested under the drop test as specified above, shall stand the number of blows at the height specified in the following table without rupture and without exceeding as the result of the first blow the deflections given:

Axle.	No. Blows.	Height of Drop.	Deflection.
M. C. B. 4¼ by 8 inch journals for 60,000-pound cars.............	5	34 feet	7 inches
M. C. B. 5 by 9 inch journals for 80,000-pound cars.............	5	43 "	5¾ "
M. C. B. 5½ by 10 inch journals for 100,000-pound cars	7	43 "	4 "

8. Axles will be considered as having failed on physical test and will be rejected if they rupture or fracture in any way, or if the deflection resulting from the first blow exceeds the following:

M. C. B. axle, 4¼ by 8 inch journals..........7½ inches.
M. C. B. axle, 5 by 9 inch journals..........6¼ inches.
M. C. B. axle, 5½ by 10 inch journals..........4½ inches.

9. Axles will be considered to have failed on chemical test and will be rejected if the analysis of the borings taken as above described gives figures for the various constituents below, outside the following limits, namely:

Carbon........below 0.35 per cent, or above 0.50 per cent.
Manganese ....above 0.60 per cent.
Phosphorus ....above 0.07 per cent.

In order to measure the deflection, prepare a straight-edge as long as the axle, by reinforcing it on one side, equally at each end, so that when it is laid on the axle, the reinforced parts will rest on the collars of the axle, and the balance of the straight-edge not touch the axle at any place. Next place the axle in position for test, lay the straight-edge on it and measure the distance from the straight-edge to the axle at the middle point of the latter. Then, after the first blow, place the straight-edge on the now bent axle in the same manner as before, and measure the distance from it to that side of the axle next to the straight-edge at the point farthest away from the latter. The difference in the two measurements is the deflection.

JOURNAL BOX, BEARING AND PEDESTAL.

At the convention of 1903 the M. C. B. journal boxes and contained parts for the 3¾ by 7 inch, 4¼ by 8 inch, 5 by 9 inch and 5½ by 10 inch standard axles, as shown on plate 1, were made a standard of the Association. They are shown on Sheets M. M. 2 to 13, inclusive. Revised 1908.

RECOMMENDATIONS.

At the convention in 1872 the following recommendations were adopted:

"In the matter of cost of keeping up the repairs of engines engaged in switching service exclusively, that an allowance of six miles per hour for the time that such engines are in actual use be allowed:

"That for engines running local freight trains an allowance of six per cent to the train mileage be added for switching:

"That where engines run empty to exceed one-half mile between where the trains are taken or left and the roundhouse, such mileage should be computed, and that for engines running through freight or passenger trains no computation should be made for switching:

AIR BRAKE AND SIGNAL INSTRUCTIONS.

At the convention of 1892 a code of Air Brake and Signal Instructions was adopted as Recommendation of the Association. Some modifications were made in 1898, and the modified rules are shown on pages 205-228, report 1898. Revised, June, 1904, as follows :

The title of the revised instructions should be,

"AIR BRAKE AND TRAIN AIR SIGNAL INSTRUCTIONS."

A.—GENERAL INSTRUCTIONS.

1. The following rules and instructions are issued for the government of all employes of this railroad whose duties bring them in contact with the maintenance or operation of the air brake and train air signal. They must be obeyed in all respects, as employes will be held responsible for the observance of same as strictly as for the performance of any other duty.

Every employe whose duties are connected in any way with the operation of the air brake will be examined from time to time as to his qualifications for such duties by the Inspector of Air Brakes or other person appointed by the proper authority, and a record will be kept of such examination.

A book of information will be issued, in convenient form, giving a complete explanation of such parts of the air brake and train air signal equipment as is deemed necessary for the care and operation of same. Any employe of this railroad whose duties require a knowledge of the operation and maintenance of the air brake and air signal will be furnished

with a copy of same upon application at place designated by special notice, and every employe will be held responsible for a full knowledge of his duties in the operation or maintenance of the air brake or signal equipment.

B.—INSTRUCTIONS TO ENGINEMEN.

Enginemen when taking charge of locomotives must see that the air brake apparatus on engine and tender is in good working order, and that the air pump and lubricator work properly; that the devices used for regulating main reservoir and train pipe pressures are adjusted at the authorized amount; that brake valve works properly in all its positions; and that, when brakes are fully applied, with cam type of driver brake the pistons do not travel less than 2 inches nor more than 3½ inches, and with other forms from 4 inches to 6 inches, and that the tender brake piston does not travel less than 6 inches nor more than 9 inches. They must know that the air signal responds by opening hose cock on its train pipe.

Enginemen must report to roundhouse foremen, in writing, at the end of the run, any defects in the air brake or train air signal apparatus.

Making up Trains, Testing Brakes at Terminal Points and Before Starting Down Such Grades as May be Designated by Special Instructions.— The train pipe under the tender must always be blown out and maximum pressure obtained in main reservoir before coupling engine to train.

After the train has been charged with air pressure, the engineman shall, at the request of the inspector or trainmen, apply the brakes with full service application and leave them so applied until all brakes operated from the engine have been inspected and the signal given to release. The engineman must then release the brakes and must not leave the station until it has been ascertained that all brakes are released and he has been informed by the inspector, or trainmen, of the number of brakes in service and their condition. In testing passenger brakes, the American Railway Association code of train air signals for applying or releasing must be used, one of which signals must be given from the discharge valve on rear car.

Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with further than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. However, when cars are added to train, the brakes on such cars must be inspected as in terminal test. When a passenger train back-up hose is to be used to control the train, the brakes must be applied for test with the back-up hose, and released from the brake valve on the locomotive.

4. Service Application.— In applying the brakes to steady the train

on descending grades, or for reducing speed for any purpose, an initial train pipe reduction of not less than five pounds must be made. Releasing brakes at low speeds must be performed with great care, dependent upon local conditions.

With freight trains, first allow the slack to run up against the locomotive. Great care must then be taken to apply the brakes with five to nine pounds reduction, according to length of train pipe, and not make a second reduction until the effect of the first reduction is felt on entire train, in order to prevent shocks which otherwise might be serious. When a freight train must be brought to a full stop, the train brakes must be held applied until stop is made.

In making a service stop with a passenger train, ALWAYS RELEASE THE BRAKES A SHORT DISTANCE BEFORE COMING TO A DEAD STOP, except on heavy grades, to prevent shocks at the instant of stopping. Even on moderate grades it is best to do this, and then, after release, to apply the brakes lightly, to prevent the train starting, so that when ready to start the release will take place quickly.

5. EMERGENCY APPLICATIONS.— The emergency application of the brakes must not be used, except in actual emergencies. Under such conditions the brake valve must be left in emergency position until train has come to a full stop.

ENGINEMAN'S STRAIGHT AIR BRAKE VALVE ON LOCOMOTIVES.

a — Always keep both brakes cut in and ready for operation, unless failure of some part requires cutting out.

b — Always carry an excess pressure of ten pounds, or more, in the main reservoir, as this is necessary to insure a uniformly satisfactory operation.

c — When using the automatic brake, keep the straight air brake valve in release position; and when using straight air, keep the automatic brake valve in running position; this to avoid driver and tender brakes sticking.

d — The straight air reducing valve should be kept adjusted at forty-five pounds, and the driver and tender brake safety valves at fifty-three pounds.

When a full application of straight air causes either or both safety valves to operate, it indicates that same are out of order, or too high adjustment of the reducing valve or too low adjustment of the safety valve, or leakage of same. Have them tested and adjusted.

6. BRAKES APPLIED FROM AN UNKNOWN CAUSE.— If it is found that the train is dragging as though the brakes were applied, without rapid falling of the train line pointer, the engineman must make an effort to release the brakes, which may be done as follows; First, if train pipe pressure is less than the authorized amount and the required excess pressure is

carried in the main reservoir, move the handle of the brake valve to the full release position for a few seconds and then return it to the running position; secondly, should the train pipe be fully charged with pressure, apply the brakes with a five or ten pounds reduction, according to the length of the train pipe, and release the brakes in the usual manner. In case the brakes can not be released, the train must be stopped and the trainmen notified to examine the brakes.

If, however, the brakes go on suddenly with a fall of the train line pointer, it is evidence that (a) a conductor's valve has been opened, (b) a hose has burst or other serious leak has occurred, or (c) the train has parted. In such an event, the locomotive throttle should be closed and the brake valve handle immediately placed on lap or emergency position, to prevent the escape of air from the main reservoir, and left there until the train has stopped and the brake apparatus has been examined and the signal to release given.

7. BRAKING BY HAND.— NEVER USE THE AIR BRAKE when it is known that the trainmen are operating the brakes of the air brake cars by hand, except in cases of emergency, as there is danger of injury to the trainmen by so doing.

8. CUTTING OUT BRAKES.— THE DRIVER AND TENDER BRAKES MUST ALWAYS BE USED AUTOMATICALLY AT EVERY APPLICATION OF THE TRAIN BRAKE, unless defective, except upon such grades as shall be designated by special instructions.

When necessary to cut out either driver or tender brake, on account of defects, it shall be done by turning the handle of the four-way cock in the triple valve down to a position midway between a horizontal and a vertical position, first releasing the brake and leaving the bleed cock open. With the special types of triple valve, close the cut-out cock in the branch pipe.

9. DOUBLE HEADERS.— When two or more locomotives are coupled in the same train, the brakes must be connected through to and operated from the head engine. For this purpose a cock is placed in the train pipe, just below the brake valve. Engineman of each locomotive except the head one must close this cock and carry the handle of brake valve in running position. He will start his air pump and let it run, as though he were going to use the brake, for the purpose of maintaining air pressure on his locomotive and enabling him to assume charge of the train brakes should occasion require it.

10. AN EXTRA AIR-BRAKE HOSE, COMPLETE, must always be carried on the locomotive, for repairs in case of burst hose. Upon locomotives having the air signal, a signal hose, complete, must also be carried for the same purpose.

C.— INSTRUCTIONS TO TRAINMEN.

11. MAKING UP TRAINS AND TESTING AIR BRAKES.— When the locomotive has been coupled to the train, or when two sections have been

coupled together, the brake and signal couplings must be united, the cocks in the train pipes — both brake and signal — must all be open, except those at the rear end of the last car, which must be closed, and the hose hung up properly in the dummy coupling, when cars are so equipped.

After the train has been charged with air, the engineman must then be requested to apply the brakes. When he has done so, the brakes of each car must be examined to see if they are properly applied. When it is ascertained that each brake is applied, the engineman must be signaled to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) The brakes of each car must then be examined to see that each is released, and the engineman informed as to the number of brakes in service and their condition.

If any defect is discovered it must be remedied and the brakes tested again — the operation being repeated until it is ascertained that everything is right. The conductor and engineman must then be notified that the brakes are all right. Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with other than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. At points where there are no inspectors, trainmen must carry out these instructions. No passenger train must be started out from an inspection point with the brakes upon any car cut out or in a defective condition, without special orders from the proper officers. The air brakes must not be alone relied upon to control any freight train with a smaller proportion of cars with the air brake in service than provided for by special instructions. When hand brakes are also used they must be applied upon those cars next behind the air-braked cars, except in cases of emergency.

12. Detaching Locomotive or Cars.— First close the cocks in the train pipes at the point of separation, and then part the couplings, invariably by hand.

13. Couplings Frozen.— If the couplings are found to be frozen together or covered with an accumulation of ice, the ice must first be removed and then the couplings thawed out by a torch to prevent injury to the gaskets.

14. Brakes Sticking.— If brakes are found sticking, the signal "brakes sticking" must be given as hereafter prescribed by the American Railway Association, or by special rules, in which case, if the brakes can not be released from the locomotive, or if the brakes are applied to detached cars, the release may be effected by opening the bleed cock in the auxiliary reservoir until the air begins to release through the triple valve, when the reservoir cock must immediately be closed.

15. Train Breaking Into Two or More Parts.— First close the

cock in the train pipe at the rear of the first section and signal the engineman to release the brakes. Having coupled to the second section, observe the rule for making up trains — first being sure that the cock in the train pipe at the rear of second section has been closed, if the train has broken into more than two sections. When the engineman has released the brakes on the second section, the same method must be employed with refence to the third section, and so on. When the train has been once more entirely united, the brakes must be inspected on each car to see that all are released before proceeding.

16. CUTTING OUT THE BRAKE ON A CAR.— If, through any defect of the brake apparatus, it becomes necessary to cut out the brake upon any car, it may be done by closing the cock in the cross-over pipe near the center of the car where the quick-action brake is used, or by turning the handle of the cock in the triple valve to a position midway between a horizontal and a vertical, where the plain automatic brake is used, first releasing the brake. With the special types of triple valves, close the cut-out cock in the branch pipe. When the brake has been thus cut out, the cock in the auxiliary reservoir must be opened and left open upon passenger cars, or held open until all the air has escaped from the reservoir upon freight cars. THE BRAKE MUST NEVER BE CUT OUT UPON ANY CAR UNLESS THE APPARATUS IS DEFECTIVE, and when it is necessary to cut out a brake the conductor must notify the engineman and also send in a report stating the reason for so doing.

17. CONDUCTOR'S VALVE.— Should it become necessary to apply the brakes from the train, it may be done by opening the conductor's valve placed in each car so equipped. THE VALVE MUST BE HELD OPEN UNTIL THE TRAIN COMES TO A FULL STOP, AND THEN MUST BE CLOSED AGAIN.

This method of stopping the train must not be used except in case of emergency.

18. BURST HOSE.— In the event of the bursting of a brake hose, it must be replaced and the brakes tested before proceeding, provided the train be in a safe place. If it is not, the train pipe cock immediately in front of the burst hose must be closed, and the engineman signaled to release. All the brakes to the rear of the burst hose must then be released by hand, and the train must then proceed to a safe place where the burst hose must be replaced and the brakes again connected and tested, so as to ascertain that the rear brakes are responsive, by test, to the brake valve on engine. One extra air brake hose complete should be carried by all crews and one extra signal hose complete carried by passenger crews for repairs.

19. BRAKES NOT IN USE.— When the air brakes are not in use, either upon the road or in switching, the hose must be kept coupled between the cars or hung up properly to the dummy couplings, when cars are so equipped.

20. PRESSURE-RETAINING VALVE.— When this valve is to be used,

the trainmen must, at the top of the grade, test the brakes upon the whole train, and must then pass over the train and turn the handles of the pressure-retaining valves horizontally upon all or a part of the cars, as may be directed. At the foot of the grade, the handles must all be turned downward again. Special instructions will be issued as to the grades upon which these valves are to be used.

21. TRAIN AIR SIGNAL.— In making up trains, all couplings and car discharge valves on the cars must be examined to see if they are tight. Should the car discharge valve upon any car be found to be defective, it may be cut out of use upon that car by closing the cock in the branch pipe leading to the valve. The conductor must always be immediately notified when the signal has been cut out upon any car, and he must report the same for repairs.

In using the signal, pull directly down upon the cord during one full second for each intended blast of the signal whistle, and allow three seconds to elapse between the pulls.

22. REPORTING DEFECTS TO INSPECTORS.— Any defect in either the air brake or air signal apparatus discovered must be reported to the inspector at the end of the run; or, if the defect be a serious one in passenger service, it must be reported to the nearest inspector, and it must be remedied before the car is again placed in service.

D.— INSTRUCTIONS TO ENGINE-HOUSE FOREMEN.

23. GENERAL.— It is the duty of the engine-house foremen to see that the air brake and signal equipment is properly inspected upon each locomotive after each run. It must be ascertained that all pipe joints, connections and all other parts of the apparatus are air tight, duplex gauges tested every thirty days, and that the apparatus is in good working order.

24. AIR PUMP.— The air pump must be tested under pressure, and if found to be working imperfectly in any respect, it must be put into thoroughly serviceable condition.

25. PUMP GOVERNOR.— The pump governor should cut off the steam supply to the pump when authorized pressure has been obtained.

26. BRAKE VALVE.— This valve must be kept clean and known to be in working order in all its positions, before the locomotive leaves the engine-house.

27. ADJUSTMENT OF BRAKES.— The driver brakes must be so adjusted that the piston travel on the cam type will be not less than 2 inches nor more than 3½ inches, and in other forms not less than 4 inches nor more than 6 inches. When the cam brake is used care must be taken to adjust both cams alike, so that the point of contact of the cams shall be in line with the piston rod. The tender brake must be adjusted by means of the dead truck levers, so that the piston travels not less than

six inches when the air brake is applied and the hand brake is released. This adjustment must be made whenever the piston travel is found to exceed nine inches.

28. Brake Cylinders and Triple Valves.— These must be examined, cleaned and lubricated at least once every six months. A record must be kept of the dates of last cleaning and lubrication of these parts for each locomotive.

29. Draining.— The main reservoir, and also the drain cup in the train pipe under the tender, must be drained of any accumulation after each trip. The auxiliary reservoirs and triple valves must also be drained frequently, and daily in cold weather, and the train pipe under the engine and tender blown out.

30. Air Signal.— The train air signal apparatus must be examined and tested by suitable appliances from both the head of the engine and the rear of the tender, to know that the whistle responds properly. A pressure gauge must be applied to the air signal pipe once each month, and oftener if found to be necessary, to ascertain that the reducing valve maintains the authorized pressure per square inch in the train signal pipe.

E.— INSTRUCTIONS TO INSPECTORS.

31. General.— It is the duty of all inspectors to see that the couplings, the pipe joints, the triple valves, the high speed reducing valve, the conductor's valves, the air signal valves, and all other parts of the brake and signal apparatus are in good order, of standard size for the car and free from leaks. For this purpose they must be tested under the full air pressure as used in service. No passenger train must be allowed to leave a terminal station with the brake upon any car cut out, or in a defective condition, without special orders from the proper officer.

If a defect is discovered in the brake apparatus of a freight car, which can not be held long enough to give time to correct such defect, the brake must be cut out and the car properly carded, to call the attention of the next inspector to the repairs required.

Special rules will specify the smallest proportion of freight cars, with the air brakes in good condition, which may be used in operating the train as an air brake train.

32. Making up Trains and Testing Brakes.— In making up trains, the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed; the inspector must know that the air is passing through the pipes to the rear end, and the couplings properly hung up to the dummy couplings if so equipped. After the train is fully charged the engineman must be requested to apply the brakes. When the brakes have been applied, they must be examined upon each car to see that they are applied with proper piston travel. This having been ascertained, the inspector

must signal the engineman to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) He must then again examine the brakes upon each car to note that all have released. If any defect is discovered, it must be corrected and the testing of the brakes repeated, until they are found to work properly. The inspector must then inform both the engineman and conductor of the number of cars with brakes in good order.

This examination must be repeated if any change is made in the make-up of the train before starting.

HIGH SPEED REDUCING VALVES ON LOCOMOTIVES AND TENDERS must be tested at least once every month, and adjusted to authorized pressure, if necessary, and cleaned and lubricated at least once in three months, and oftener if tests show that same is necessary.

33. CLEANING CYLINDERS AND TRIPLE VALVES.— The brake cylinders and triple valves must be kept clean and free from gum. They must be cleaned and lubricated as often as once in six months upon passenger cars, and once in twelve months upon freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinder or reservoir, in the space left opposite the words:

Cylinder, cleaned and lubricated..............................
Triple, cleaned and lubricated..................................

The triple valves and auxiliary reservoirs must be frequently drained, especially in cold weather, by removing the plug in the bottom of the triple valve and opening the bleed cock in the reservoir.

34. GRADUATING SPRINGS.— The graduating springs in the Westinghouse quick-action freight triple valves are .049 inch in diameter, nickeled-steel wire, 16 coils, 2¾ inches free height, 29-64 inch inside diameter, and in passenger .08 inch diameter, nickeled-steel wire, 13¼ coils, 2⅝ inches free height, 29-64 inch inside diameter. The graduating springs used in the Westinghouse plain triple valve in locomotive service are made of phosphor-bronze wire, .083 inch in diameter, 12 coils, 2½ inches free height, 25-64 inch inside diameter.

35. ADJUSTMENT OF BRAKES.— The slack of the brake shoes must be taken up by means of the dead truck levers.

In taking up such slack it must be first ascertained that the hand brakes are off, and the slack is all taken out of the upper connections, so that the truck levers do not go back within one inch of the truck timber or other stop, when the piston of the brake cylinder is fully back at the release position. When under a full application the brake piston travel is found to exceed nine inches upon passenger or freight cars, the brake shoe slack must be taken up and the adjustment so made that the piston shall travel not less than six inches. In taking up the brake shoe slack it must never be taken up by hand brakes. Where automatic slack

adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

36. Braking Power.— Where the cylinder lever has more than one hole at the outer end the different holes are for use upon cars of different weights.

It must be carefully ascertained that the rods are connected to the proper holes, so that the correct braking power shall be exerted upon each car.

37. Repair Parts.— Inspectors must keep constantly on hand for repairs a supply of all parts of the brake and signal equipment that are liable to get out of order.

38. Hanging Up Hose.— Inspectors must see that, when cars are being switched or standing in the yard, the hose is coupled between the cars or properly secured in the dummy couplings, when cars are so equipped.

39. Responsibility of Inspectors.— Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make any examination of brake apparatus or repairs to the same which they may be called upon to do by trainmen.

GENERAL QUESTIONS REGARDING THE USE OF THE AIR BRAKE AND TRAIN AIR SIGNAL.

GENERAL.

(All parties who have to do with the use, adjustment, care or repairs of air brakes should be thoroughly examined on these questions, in addition to the special questions for each class of men following them.)

1. Question. What is an air brake?

Answer. It is a brake applied by compressed air.

2. Q. How is the air compressed?

A. By an air pump on the locomotive.

3. Q. How does the compressed air apply the brakes?

A. It is admitted into a brake cylinder on each car, and it pushes out a piston in that cylinder, which pulls the brake on.

4. Q. How does the piston get back when the brakes are released?

A. There is a spring around the piston rod which is compressed when the brakes are applied, and when the air is allowed to escape to release the brakes, this spring reacts and pushes the piston in again.

5. Q. Where is the compressed air kept ready for use in the automatic air brake?

A. In the main reservoir on the locomotive, in the smaller or auxiliary reservoir on each car, and in the train pipe.

6. Q. Where does the compressed air come from directly that enters into the brake cylinder when the automatic brake is applied?

A. It comes from the auxiliary reservoir on each car in service application, and from the auxiliary reservoir and train pipe in emergency application.

7. Q. How does it get into the auxiliary reservoir?

A. It is furnished from the main reservoir on the locomotive through the train pipe and triple valve when the brakes are released.

8. Q. How is the automatic brake applied and released?

A. The automatic brake is applied by reducing the air pressure in the train pipe below that in the auxiliary reservoir, and is released by raising the train pipe pressure above that remaining in the auxiliary reservoir.

9. Q. Why does the compressed air not enter directly into the brake cylinder from the train pipe?

A. Because the triple valve used with the automatic brake prevents the air from entering directly from the train pipe to the brake cylinder when the pressure in the train pipe is maintained or increased.

10. Q. What other uses has the triple valve ?

A. It causes the brake cylinder to be opened to the atmosphere under each car, to release the brakes when the pressure in the train pipe is made greater than that in the auxiliary reservoir, and it opens communication from the train pipe to the auxiliary reservoir by the same movement; when the pressure in the train pipe is reduced it closes the openings from the train pipe to the auxiliary reservoir and from the brake cylinder to the atmosphere, and then opens the passage between the auxiliary reservoir and the brake cylinder by the same movement, so as to admit the air and apply the brakes.

11. Q. How many forms of triple valves are there in use, and what are they called?

A. Two; the plain triple and the quick-action triple.

12. Q. How can you tell the plain triple from the quick-action triple?

A. The plain triple has a four-way cock in it, with a handle for operating the cock; the quick-action triple has no such cock in it, but there is a plug cock in the cross-over pipe leading from the train pipe to the triple, when the quick-action triple is used.

13. Q. What are these cocks for in both cases?

A. They are to be used to cut out brakes on one car, without interfering with other brakes on the train, if the brake on that car has become disabled.

14. Q. How does the cock handle stand in the plain triple when the pipe is open for automatic action?

A. It stands in a horizontal position.

15. Q. In what position does the same handle stand when the brakes are cut out by closing the cock?

A. It stands at an inclined position midway between horizontal and vertical.

16. Q. How does the handle in the plug cock in the cross-over pipe, used with the quick action triple, stand for automatic action?

A. It stands with the handle crosswise with the pipe, and groove in plug lengthwise when cock is open.

17. Q. How does the handle and groove stand when the cock is closed and brake cut out of action?

A. It stands with the handle lengthwise of cross-over pipe, and the groove crosswise when closed.

18. Q. How is the train pipe coupled up between the cars?

A. By means of a rubber hose on each end of the train pipe, fitted with a coupling at the loose end.

19. Q. How is the train pipe closed at the rear end of train?

A. By closing the cock in the train pipe at the rear end of last car.

20. Q. How many such train pipe cocks are there to a car, on the air brake train pipe and on the air signal train pipe, and why?

A. Two for each pipe on each car, because either end of any car may sometimes be at the rear end of the train.

21. Q. How many kinds of train pipe cocks are there in use at the ends of the cars?

A. Two.

22. Q. Describe each and give the position of the handle and groove for open and closed in each case.

A. The older form of train pipe cock is a straight plug cock in the train pipe, not far from the hose connection; the handle stands crosswise with the pipe when it is open, and lengthwise with the pipe when closed; it is now found principally on the air signal pipe. The other form of train pipe cock now used on the air brake pipe is an angle cock placed at the end of the train pipe and close to the hose. The handle of the angle cock stands lengthwise with the pipe when open, and crosswise with the pipe when closed. The groove is also a guide to tell whether open or closed.

23. Q. What uses have these train pipe cocks besides to close the pipe at the end of the train?

A. They are used to close the train pipe at both sides of any hose coupling which is to be parted, as when the train is cut in two.

24. Q. Why is it necessary to close the train pipe on both sides of the hose coupling before it is parted?

A. To prevent the escape of air from the train pipe, which would apply the brakes.

25. Q. How must the hose coupling be parted when it is necessary to do so, and why?

A. The air brake must first be released on the train from the locomotive, then the adjacent train pipe cocks must both be closed and the coupling must be parted by hand, to prevent the possibility of injury to the rubber gasket in the coupling.

26. Q. Why must the brakes be fully released before uncoupling the hose between the cars?

A. Because if the brakes are applied upon a detached car they can not be released without bleeding the auxiliary reservoir.

27. Q. In coupling or uncoupling the hose between cars, what must be done if there is ice on the couplings?

A. The ice must first be removed and the couplings thawed out, so as to prevent injury to the rubber gaskets in uncoupling, and to insure tight joints in coupling the hose.

28. Q. What must be done with a hose coupling which is not coupled up, such as the rear hose of a train, or any hose on a car which is standing or running, but not in use?

A. It must be placed in the dummy coupling if provided for in such manner that the flat pad on the dummy will close the opening in the coupling.

29. Q. What pressure should be carried in the train pipe and auxiliary reservoir?

A. The authorized pressure, as per special instructions.

30. Q. Why should the authorized pressure be maintained?

A. Because this pressure is necessary to get the full braking force which each car is capable of using, and, if it be exceeded, there will be danger of sliding the wheels.

31. Q. How much pressure can be obtained in the brake cylinder by the service application of the brakes with seventy pounds in the auxiliary reservoir?

A. About fifty pounds to the square inch, with an 8-inch piston travel.

32. Q. Why can only fifty pounds pressure be obtained under these circumstances?

A. Because the air at seventy pounds pressure in the auxiliary reservoir expands into an additional space when the auxiliary reservoir is opened to the brake cylinder, and when the pressure has become equalized it is thus reduced to fifty pounds.

33. Q. How much must the train pipe pressure be reduced, in order to get fifty pounds pressure in the brake cylinder, in ordinary service?

A. Twenty pounds.

34. Q. Can the brakes be applied so as to get only a portion of this fifty pounds pressure in the brake cylinder, and how?

A. They can be so applied by reducing the train pipe pressure less than twenty pounds.

35. Q. If the train pipe pressure be reduced ten pounds, what will be the pressure in the brake cylinder?

A. About twenty-five pounds.

36. Q. How is this graduated action obtained?

A. By means of the graduating valve in the triple valve.

37. Q. Is it important to keep all the air brake apparatus tight and free from leaks?

A. Yes.

38. Q. Why is this important?

A. In order to get full service from the air brakes, and to prevent the waste of air, and also to prevent the brakes applying automatically by reason of leak in the train pipe.

39. Q. Is it important to know that the train pipe is open throughout the train and closed at the rear end before starting out?

A. Yes, this is very important.

40. Q. Why is this very important?

A. Because if any cock in the train pipe were closed, all the brakes back of the cock which is closed would be prevented from working.

41. Q. How can you ascertain that the train pipe cocks are all open when the train is made up?

A. By testing the brakes; that is, by applying and releasing them, and observing whether they all operate.

42. Q. Do you understand that no excuse will be acceptable for starting out the train without first testing the air brakes?

A. Yes.

43. Q. Why is this rule absolute?

A. Because the safety of passengers and of property depends upon the brakes being properly coupled up and in an operating condition before the train is started.

44. Q. At what other times should the brakes be tested?

A. After each change in the make-up of the train and before starting the train down certain designated grades.

45. Q. From where does the air signal apparatus receive its pressure?

A. From the main air reservoir through the reducing valve.

46. Q. How much air pressure should be carried in the air signal train pipe?

A. The authorized pressure.

47. Q. Is it important that this train pipe and its connections be also kept tight?

A. Yes.

48. Q. After taking up the slack of the brake shoes, how far should the brake piston travel in the cylinders on cars and tenders with a full application of the brake?

A. Not less than six inches, nor more than nine inches.

49. Q. What would happen if the piston traveled less than six inches when brakes are fully applied?

A. A partial application of the brakes might not force the piston beyond the leakage groove in the brake cylinder provided for the escape of small amounts of air.

50. Q. Why should the piston travel not be permitted to exceed nine inches on passenger cars, tenders, or freight cars?

A. Because if it travels farther than this when sent out, a little wear of the brake shoes will cause the piston to travel far enough to rest against the back cylinder head when the brakes are applied, and this cylinder head would then take the pressure instead of its being brought upon the brake shoes.

51. Q. How far should the driver brake piston travel with a full application of the brakes, and why?

A. Not less than two inches nor more than three and one-half inches for the cam type of brake, and from four to six inches for other forms.

52. Q. If the brakes stick upon any car so that the engineman can not release them at any time, how should they be released?

A. By opening the release cock in the auxiliary reservoir and holding it open until air begins to escape from the triple valve, and then closing it again.

53. Q. What is the pressure retaining valve, and what is its use?

A. The pressure retaining valve is a small valve placed at the end of a pipe from the triple valve, through which the exhaust takes place from the brake cylinder. It is used to retard the brake release on heavy grades, and holds the brakes partially applied, so as to allow more time for the engineman to recharge the auxiliary reservoir.

54. Q. What precautions are necessary on every train in regard to hose couplings?

A. Every train must carry at least two extra hose and couplings complete, for use in replacing any hose couplings which may fail or become disabled. These extra hose and couplings to be carried on such part of the train as is required by the rules and regulations.

SPECIAL FOR ENGINEMEN.

55. Q. How should the air pump be started?

A. It should be started slowly, so as to allow the condensation to escape from the steam cylinder and prevent pounding, which is more likely to occur when the air pressure is low.

56. Q. Why should the piston rod on the air pump be kept thoroughly packed?

A. To prevent the waste of air and steam.

57. Q. How should the steam cylinder of the air pump be oiled, and what kind of oil should be used?

A. It should be oiled as little as necessary through a sight-feed lubricator, and cylinder oil should be used.

58. Q. How should the air cylinder of the air pump be oiled; what kind of oil?

A. It should be supplied with valve oil as often as necessary, through a cup provided for that purpose. Also, a well saturated swab should be kept on the piston rod. Lard oil, and other animal or vegetable oils should not be used, as their use causes the brake valve and the triple valves to gum up. The oil must never be introduced through the air inlet ports, as this practice would cause the pump valves to gum up.

59. Q. What regulates the train pipe pressure?

A. The train pipe governor, or feed valve, provided for that purpose.

60. Q. Why should the authorized pressure be carried in train pipe?

A. Because this pressure produces the strongest safe pressure of the brake shoes upon the wheels. A higher train pipe pressure is liable to cause the wheels to slide.

61. Q. What does the feed valve attachment on the brake valve accomplish?

A. When properly adjusted it restricts the train pipe pressure to the authorized amount, with the brake valve handle carried in running position.

62. Q. How often should the brake valve be thoroughly cleaned and oiled?

A. At least once every two months.

63. Q. If the main valve in the brake valve is unseated by dirt or by wear, what may be the result, and what should be done?

A. It may be impossible to get the excess pressure; when the brakes have been applied they may keep applying harder until full on, or when they have been applied they may release. The main valve should be thoroughly cleaned, and if worn it should be faced to a seat.

64. Q. If the piston in the brake valve becomes gummed up or corroded from neglect to clean it, what will be the result?

A. It will be necessary to make a large reduction of pressure through the preliminary exhaust port before the brakes will apply at all, and then the brakes will go on too hard and will have to be released.

65. Q. How and why should the train pipe under the tender always be blown out thoroughly before connecting up to the train?

A. By opening the angle cock at the rear end of the tender and allowing the air from the main reservoir to blow through. This blows

out the oil, water, scale, etc., which may accumulate in the pipe, and which would be blown back into the train pipe and triple valves if not removed before coupling to the train.

66. Q. When the locomotive is coupled to the train, why is it necessary to have excess pressure in the main reservoir?

A. So that the brakes will all be released and the train quickly charged when the engineman's valve is placed in the release position.

67. Q. Why should the driver brakes be operated automatically with the train brake?

A. Because it adds greatly to the braking force of the train, and the brakes can be applied alike to all the wheels for ordinary stops, and in an emergency the greatest possible braking force is at once obtained by one movement of the handle.

68. Q. In making a service application of the brakes, how much reduction of the train pipe pressure from seventy pounds does it require to get the brakes full on?

A. About twenty-five pounds reduction.

69. Q. What should the first reduction be in such an application?

A. Not less than five pounds, so as to insure moving the pistons in the brake cylinders past the leakage grooves.

70. Q. What is the result of making a greater reduction of pressure than twenty-five pounds?

A. A waste of air in the train pipe, without getting any more braking force, and therefore requiring more air to release the brakes.

71. Q. How many applications of the brakes are necessary in making a stop?

A. One or two applications.

72. Q. Why is it dangerous to apply and release the brakes repeatedly in making stops?

A. Because every time the brakes are released the air in the brake cylinders is thrown away, and if it is necessary to apply them again before sufficient time has elapsed to recharge the auxiliary reservoirs the application of the brakes will be weak, and after a few such applications the brakes are almost useless on account of the air having been exhausted from the auxiliary reservoirs.

73. Q. In releasing and recharging the train, how long should the handle of the brake valve be left in the release position?

A. Until the train pipe pressure has risen nearly to authorized pressure.

74. Q. In making service stops with passenger trains, why should you release the brakes just before coming to a full stop?

A. So as to prevent stopping with a lurch; it also requires less time for the full release of the brakes after stopping.

75. Q. In making stops with freight trains, why should the brakes not be released until after the train has come to a full stop?

A. Because long freight trains are apt to be parted by releasing the brakes before rear brakes are fully released.

76. Q. In making service stops, why must the handle of the brake valve not be moved past the position for service applications?

A. So as to prevent unnecessary jerks to the train and the emergency action of the triple valve when not necessary.

77. Q. If you find the train dragging from the failure of the brakes to release, how can you release them?

A. By placing the handle of the brake valve in full release position for a few seconds and returning it to the running position, if the train pipe pressure is not up to the authorized amount; but if maximum pressure is in train pipe, the brakes should be applied with from five to ten pounds reduction, according to the length of train pipe, and released in the usual manner.

78. Q. When the brakes go on suddenly when not operated by the brake valve, and the gauge pointer falls back, what is the cause, and what should you do?

A. Either a hose has burst, or a conductor's valve has been opened, or the train has parted. In any event, the engine throttle should be closed and the handle of the brake valve should immediately be placed on lap position to prevent escape of air from main reservoir.

79. Q. Are the brakes liable to stick after an emergency application, and why?

A. The brakes are harder to release after an emergency application because they are on with full force and it requires higher pressure than usual in the train pipe to release them again. In this case it is necessary always to have in reserve the excess pressure of the main reservoir to aid in releasing the brakes. With the quick-action triple valve this is especially necessary, because air from the train pipe as well as from the auxiliary reservoir is forced into the brake cylinder when a quick application of the brake is made, thus increasing the pressure in the brake cylinder without the usual reduction of pressure in the auxiliary reservoir, and requiring a correspondingly high pressure in the train pipe afterward to cause the brakes to be released.

80. Q. In using the brakes to steady the train while descending grades, why should the air pump throttle be kept well open?

A. So that the pump may quickly accumulate a full pressure in the main reservoir for use in recharging the train pipe and auxiliary reservoir when the brakes have been released again.

81. Q. In descending a grade, how can you best keep the train under control?

A. First, by commencing the application of the brakes early, so as

to prevent too high a speed being reached; secondly, by making an initial reduction that will lightly apply all brakes in the train, and by slowing the train down just before it is necessary to charge the auxiliary reservoir, so as to give time enough to refill same before much speed is again attained.

82. Q. If the train is being drawn by two or more locomotives, upon which locomotives should the brakes be controlled, and what must the engineman of the other locomotive do?

A. The brakes must be controlled by the leading locomotive, and the enginemen of the following locomotives must close the cock in the train pipe just below the brake valves. The latter must always keep the pump running and in order, and main reservoir charged with pressure, with the brake valve in the running position, so that he may quickly operate the brakes if called upon to do so.

83. Q. If the air signal whistle gives only a weak blast, what is the probable cause?

A. Either the reducing valve is out of order so that the pressure is considerably less than forty pounds, or the whistle itself is filled with dirt or not properly adjusted, or the port under the end of signal valve is partly closed by gum or dirt.

84. Q. If the reducing valve for the air signal is allowed to become clogged up with dirt, what will the result probably be?

A. The signal pipe might get the full main reservoir pressure, and the whistle will blow when the brakes are released.

85. Q. If you discover any defect in the air brake or signal apparatus while on the road, what must be done?

A. If it is something that can not be readily remedied at once, it must be reported to the Enginehouse Foreman as soon as the run is completed.

86. Q. What is the result if water be allowed to collect in the main reservoir of the brake apparatus?

A. The room taken up by the water reduces the capacity for holding air, and the brakes are more liable to stick. In cold weather also the water may freeze and prevent the brakes from working properly.

SPECIAL FOR ENGINE REPAIRMEN.

87. Q. How often must the air brake and signal apparatus on locomotives be examined?

A. After each trip.

88. Q. Under what pressure must it be examined?

A. Under full pressure.

89. Q. Should the train pipe pressure exceed the maximum, where would you look for the cause of the trouble?

A. In the devices controlling train pipe pressure.

90. Q. How often must the main reservoir and the drain cup under the tender be drained?

A. After each trip.

91. Q. How often must the triple valves and the cylinders of the driver and tender brakes be cleaned and lubricated?

A. They must be thoroughly cleaned and lubricated once every six months. If the driver brake cylinders are so located that they become hot from the boiler, they may acquire lubrication more frequently.

92. Q. If there are any leaks in the pipe joints or anywhere in the apparatus, what must you do?

A. Repair them before the locomotive goes out.

93. Q. How is the brake shoe slack of the cam driver brake taken up, and what precautions are necessary?

A. By means of the cam screws, and it is necessary to lengthen both alike, so that when the brake is applied the point of contact with the cams will be in a line with the piston rod.

94. Q. How is the brake shoe slack of driver brakes on a locomotive with more than two pairs of driving wheels taken up?

A. By means of a turnbuckle or screw in the connecting rods.

95. Q. How is the slack of the tender brake shoes taken up?

A. By means of the dead truck levers; if they will not take it up enough, it must be taken up in the underneath connection, and then adjusted by the dead lever.

96. Q. How far should the driver brake piston travel in applying the brakes?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other forms.

97. Q. What travel of piston should the tender brakes be adjusted for?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other eight inches.

SPECIAL FOR TRAINMEN.

98. Q. How should you proceed to test the air brakes before starting out, after a change in the make-up of a train, or before descending certain specially designated grades?

A. After the train has been fully charged with air, the engineman must be required to apply the brakes; when he has done so the brakes

must be examined upon each car to see that the air is applied and that the piston travel is not less than six nor more than nine inches. The engineman must then be required to release the brakes; after he has done so, each brake must be examined again to see that all are released. The engineman and conductor must then be notified that the brakes are all right, if they are found so. (In testing passenger brakes, the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.)

99. Q. In starting out a passenger train from an inspection point, how many cars must have the brakes in service?

A. Every car in the train.

100. Q. When might you cut out a brake upon a passenger car?

A. Never, unless it gets out of order while on the run, in which case it must be reported to the inspector at the end of the run, or upon the first opportunity which may give sufficient time to repair it.

101. Q. If a hose bursts upon the run what must be done, if the train is in a safe place?

A. The hose must first be replaced by a good one, and the engineman then signaled to release the brakes. The train must not proceed until the brakes have been reconnected and tested upon the train to see that all are working properly.

102. Q. If the train is not in a safe place when the hose bursts, what must be done?

A. The train pipe cock immediately ahead of the burst hose must be closed and the engineman signaled to release the brakes. The brakes at the rear of the burst hose must then be released by bleeding the auxiliary reservoirs, and the train must then proceed to a safe place to replace the hose and connect up the brakes, after which the brakes must be tested.

103. Q. If the train breaks in two, what must be done?

A. The cock in the train pipe at the rear end of the first section must be closed and the engineman signaled to release the brakes. The two parts of the train must then be coupled, the hose connected and the brakes again released by the engineman. When it is ascertained that the brakes are all released, the train may proceed.

104. Q. Explain how the pressure-retaining valves are thrown into action or thrown out of action, and when this must be done.

A. The pressure-retaining valve is thrown into action by turning the handle of the valve to a horizontal position, and it is thrown out of action again by placing this handle in a vertical position pointing downward. This handle should be placed in a horizontal position at the top of a heavy grade, and it should always be returned to a vertical position at the foot of the grade, as otherwise the brakes will drag on any cars which still have the handle of the pressure-retaining valve in the horizontal position.

105. Q. If the brake of any car is found to be defective on the run, how should you proceed to cut it out?

A. By closing the cock in the cross-over pipe of the quick-action brake, or in the triple valve of the plain automatic brake, and then opening the release cock in the auxiliary reservoir upon that car, leaving it open, if a passenger car, or holding it open until all the air has escaped from it, if a freight car.

106. Q. When it is necessary to cut out a defective brake upon a car, why should it always be cut out at the triple valve and never by the train-pipe cock at the end of the car, even if it is the last car of the train?

A. The train pipe should always be open from the locomotive to the rear end of the last car, so that if the train breaks in two the brakes will be automatically applied before the parts of the train have separated sufficiently to permit damage to be done by their coming together again, and so that the brakes may be applied with the conductor's valve upon any car.

107. Q. Should the train pipe burst under any car, what must be done?

A. The train must proceed to the nearest switching point, using the brakes upon the cars ahead of the one with the burst pipe, where the car with the burst pipe must be switched to the rear of the train; the hose must then be coupled up to the rear car and the cock at the rear end of the next to the last car opened, and the cock at the forward end of the last car closed, so that if the train should part between the last two cars the brakes will be applied.

108. Q. What is the conductor's valve, and what is its use?

A. It is a valve at the end of a pipe leading from the train-brake pipe upon each passenger car; it is to be opened from the car in any emergency when it is necessary to stop the train quickly, and only then. When used it should be held open until the train is stopped, and then it should be closed.

109. Q. What is the air signal for, and how is it operated?

A. It is to signal the engineman, in place of the old gong signal, and it is operated by pulling directly downward on the cord for one second and releasing immediately, allowing three full seconds to elapse between pulls.

110. Q. If the discharge valve on the air-signal system is out of order or leaking on any car, how can you cut it out?

A. By closing the cock in the branch pipe leading from the train-signal pipe to the discharge valve; to do so the handle of this cock should be placed lengthwise with the pipe.

111. Q. How is the slack taken up so as to secure the proper adjustment of piston travel?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the

adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

SPECIAL FOR INSPECTORS.

112. Q. Do you understand that no passenger train may be started out with any of the brakes cut out of service?

A. I do.

113. Q. Why is it important that no leaks should exist in the air brake service?

A. Because they would interfere with the proper working of the brakes and might cause serious damage.

114. Q. What must be done with the air brake or air-signal couplings when not united to other couplings, on cars equipped with dummy couplings?

A. They must be secured in the dummy coupling, so that the face of the dummy coupling will cover the opening of the hose coupling so as to prevent dust and dirt from entering the hose.

115. Q. If the air issues from the exhaust port of the quick-action triple valve when the brakes are off, what is the cause?

A. It is probably due to dirt on the rubber seated emergency valve.

116. Q. How often must the cylinder and triple valves be examined, cleaned and lubricated?

A. As often as once every six months on passenger cars and once in twelve months on freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinders.

117. Q. What is the difference between the quick-action passenger and freight triple valve?

A. The passenger triple valves have larger ports and slide valves.

118. Q. How may a passenger triple valve be distinguished?

A. By having one exhaust outlet, or suitable lettering designating the class of service.

119. Q. How may a freight triple valve be distinguished?

A. By its two exhaust outlets, one being plugged.

120. Q. When should the graduating spring of the triple valve be replaced with a new one?

A. When it is worn or rusted out, or not of standard size.

121. Q. To what travel of piston must the brakes be adjusted?

A. Not less than six inches, and this adjustment must be made whenever the piston travel is found to exceed nine inches.

122. Q. How is the slack taken up so as to secure this adjustment?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the

adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

123. Q. What are the different holes in the outer end of the cylinder levers for, and why must the connections be pinned to the proper hole for each car?

A. These holes are to enable the adjustment of the brake pressure to be made according to the weights of the different cars. The connection must be made to the proper hole in each case, according to the weight of the car, so as to give proper braking power, otherwise the brake will be inefficient, or the wheels may be slid under the cars.

124. Q. How many sizes of high speed brake-reducing valves are there in use, and how will it be known to which size of cylinders they should be connected?

A. There are three sizes, namely, one for 8-inch, one for 10-inch and 12-inch, and a third for 14-inch and 16-inch cylinders, and they can be distinguished by the raised figures cast on their body.

125. Q. To what pressure must the high speed brake-reducing valve be adjusted on passenger equipment cars?

A. The authorized pressure.

BASIC PRINCIPLES RELATING TO THE HANDLING OF APPRENTICES.

At the convention of 1898 a code of apprenticeship rules was adopted as the Recommendation of the Association. In 1908 a series of basic principles relating to the handling of apprentices was adopted in lieu of the former code.

1. To develop from the ranks in the shortest possible time carefully selected young men for the purpose of supplying leading workmen for future needs, with the expectation that those capable of advancement will reveal their ability and take the places in the organization for which they are qualified.

2. A competent person must be given the responsibility of the apprenticeship scheme. He must be given adequate authority, and he must have sufficient attention from the head of the department. He should conduct thorough shop training of the apprentices, and in close connection therewith should develop a scheme of mental training, having necessary assistance in both. The mental training should be compulsory, and conducted during working hours at the expense of the company.

3. Apprentices should be accepted after careful examination by the apprentice instructor.

4. There should be a probationery period before apprentices are finally accepted; this period to apply to the apprentice term if the candidate is accepted. The scheme should provide for those candidates for appren-

ticeship who may be better prepared as to education and experience than is expected of the usual candidate.

5. Suitable records should be kept of the work and standing of apprentices.

6. Certificates or diplomas should be awarded to those successfully completing the apprentice course. The entire scheme should be planned and administered to give these diplomas the highest possible value.

7. Rewards in the form of additional education, both manual and mental, should be given apprentices of the highest standing.

8. It is of the greatest importance that those in charge of apprentices should be most carefully selected. They have the responsibility of preparing the men on whom the roads are to rely in the future. They must be men possessing the necessary ability, coupled with appreciation of their responsibility.

9. Interest in the scheme must begin at the top, and it must be enthusiastically supported by the management.

10. Apprenticeship should be considered as a recruiting system, and greatest care should be taken to retain graduated apprentices in the service of the company.

RESOLUTIONS.

Revised and modified at convention, 1903.

At the convention of 1886 the following resolutions prevailed:

Resolved, That this Association deprecates the giving of testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry. (See page 26, report 1886.)

Resolved, That it is the sense of this convention that in practice it is unnecessary to bead flues in the front end. (See page 152, report 1886.)

At the convention of 1888 the following resolution prevailed:

Resolved, That it is the sense of the Master Mechanics' Association that the pilots of all engines should have steps placed on the front end for the safety and convenience of brakemen while coupling at the front ends. (See page 162, report 1888.)

At the convention of 1893 the following resolution prevailed:

Resolved, That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives. (See page 161, report 1893.)

At the convention of 1896 the following resolutions prevailed:

Resolved, That it is the sense of this meeting that the radial stay boiler is as safe as the crown bar boiler, and that the former is easier to keep clean and more economical in repairs. (See page 280, report 1896.)

Resolved, That it is the sense of this Association that the statement of the performance of locomotives should be made on the basis of train load, in lieu of train miles or loaded car miles, as is the prevailing practice at present. (See page 333, report 1896.)

At the convention of 1899 the following resolutions prevailed:

Resolved, That it is the sense of this convention that the time has not arrived when we can abandon instructions to those who use the air brakes, but that the time has arrived when we should perhaps take more care to instruct those who repair the brakes and keep them in order. (See page 71, report 1899.)

Resolved, That it is the sense of the American Railway Master Mechanics' Association that the use of fusible plugs in the crown sheets of locomotive fire boxes is not conducive to the prevention of the overheating of the crown sheet. (See page 153, 1899 report.)

Resolved, That it is the sense of this Association that the ton-mile basis for motive power statistics is the most practical, and encourages economical methods of operating; and that it is desirable that the heads of motive power departments urge its adoption on their managements. (See page 173, report 1899.)

Resolved, That it is the sense of this Association that it is not advisable to use bars in exhaust nozzles. (See page 277, report 1899.)

At the convention of 1901 the following resolutions prevailed:

Resolved, That it is the sense of this Association that a strict comparison of motive power statistics, one road with another, will not secure the best results, but that such comparisons should be made with the records of the same division for preceding periods of time. (See page 79, report 1901.) (See modification, page 70, 1902 report.)

Resolved, That it is the sense of this Association that the ton-mileage of the locomotive is a just credit to the motive power department for statistical purposes. (See page 83, report 1901.) (See modification, page 77, 1902 report.)

Resolved, That it is the sense of this Association that it is necessary that the side rods should be on engines traveling from the works to the railroad they are built for. (See page 99, report 1901.)

At the convention of 1902 the following resolutions prevailed:

"*Resolved,* That it is the sense of this Association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable."

"*Resolved,* That it is the sense of this Association that the ton-mileage of the locomotive and caboose is a just credit to the motive power department for statistical purposes."

"*Resolved,* That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

"*Resolved,* That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

"*Resolved,* That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service to be each further grouped under Through and Local.

"*Resolved,* That the statistics of branch lines and main lines should be kept separately.

"*Resolved,* That the credit of ton-mileage for locomotives in switching service should be proportional to their tractive power.

"*Resolved,* That the ton-mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

"*Resolved,* That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water."

At the convention of 1906 the following motion was adopted:

That twenty-four hours be adopted as the limit distinguishing between engines in service and those under repairs, and that $100 be adopted as the limit distinguishing between running and shop repairs.

Obituary.

MATTHIAS NACE FORNEY.

Matthias Nace Forney, the designer of the most successful suburban locomotive ever introduced and a celebrated mechanical engineer and accomplished engineering writer, was born in Hanover, Pennsylvania, in 1835, of German stock and died at New York on January 14, 1908.

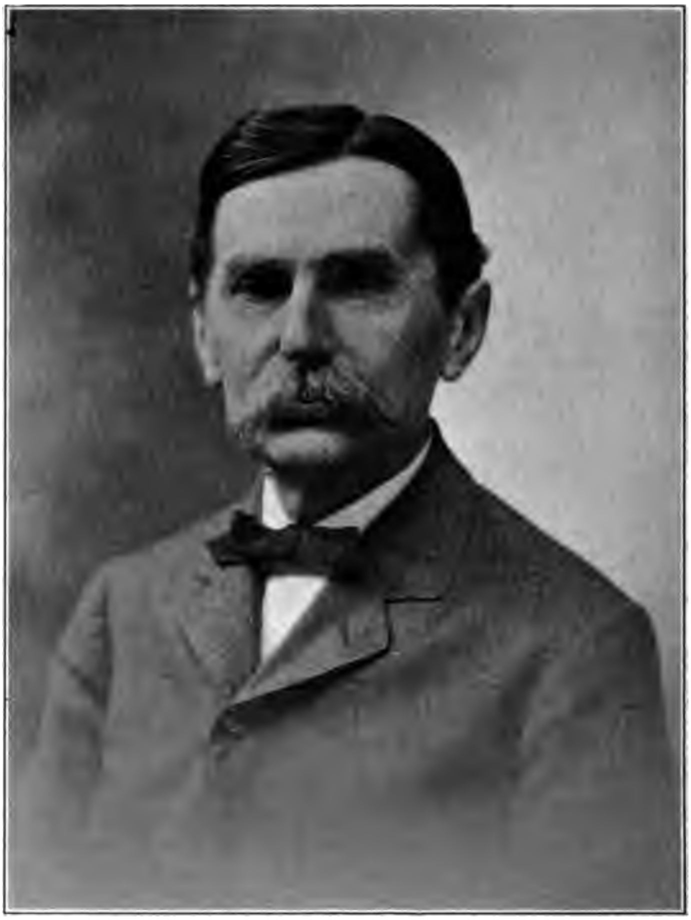
His father died when Matthias was twelve years old, leaving the mother with three sons and three daughters. Hanover having had at that time very indifferent school facilities, Matthias was sent to school in Baltimore, which had something of a high school character. He early displayed a strong tendency toward mechanism and science, one of his earliest ambitions having been to make a steam engine. With such tastes it was not surprising to find that he entered the shops of the great pioneer locomotive builder, Ross Winans, as an apprentice in 1852. He spent three years working in the shops and one year in the drawing office. At the end of his apprenticeship he obtained a position as draughtsman in the shops of the Baltimore & Ohio, then in charge of Henry Tyson. He remained in that position three years.

Thinking that prospects of success in life were very meager on railroads, Mr. Forney left railroad work and entered mercantile business in Baltimore. But the attractions of machinery were upon him and three years of business found him ready to return to his first love. The resulting change was to enter the employ of the Illinois Central as draughtsman under Samuel J. Hayes, superintendent of machinery.

In the course of an autobiography presented to the New York Railroad Club in 1902 Mr. Forney said concerning the Chicago period of his career:

"During my employment on the Illinois Central Railroad their shops were located in Chicago near where the present passenger station now stands. To show how slight events sometimes lead to more important ones, it will be explained that my boarding place was then in Wabash avenue, near Washington street, a locality now covered with sky-scrapers, and my daily walk was on Michigan avenue to and from the shops. The track of the Illinois Central Road then extended on piling over the lake, and from the shops to the station, which was then about a mile farther north. There were at that time on the road some four-wheeled switching engines which weighed about 20 tons and had four-wheeled tenders.

These engines would pull as heavy a train as the heavier eight-wheeled "American" engines with four coupled wheels and weighing 30 tons. In my daily walks in pursuit of Chicago nutriment, I saw these switching engines backing up to the shops on the track which was in plain view. The question consequently occurred to me, 'If the little engines will pull as much as the big ones, why are the little ones not used in general road



M. N. Forney

service?' As the road in this location was in plain view from Michigan avenue, and the engines and tenders showed distinctly in side elevation while running to and fro, it was apparent that having a short wheel base they were very unsteady. The idea then occurred to me why not connect the engine and tender by a rigid frame and put a truck under the tender? This would give a long wheel base with steadiness, and retain the whole weight of the boiler and engines on the driving wheels for adhesions. This was the origin of what has since been known as the 'Forney' engine, of which the annexed figure is a representation."

After some persistent efforts Mr. Forney and his friends succeeded in getting Forney locomotives placed upon the elevated railroads in New York and they operated so successfully in that service that they became the motive power for all the elevated and many surface suburban railroads. They held constant favor for that work until they were displaced by electric motors.

After serving the Illinois Central for three years Mr. Forney went to be draughtsman with the Detroit Iron & Bridge Works, but remained there only a short time, having been engaged by the president of the Illinois Central Railroad to superintend the building of some locomotives under construction at the Hinkley & Williams Works in Boston. This was in the spring of 1865 and occupied Mr. Forney about six months. On the completion of the engines Mr. Forney remained with Hinkley & Williams about three years as mechanical engineer and agent.

When the inspiration is given a person to express thought and ideas in writing the tendency to do so will not long remain suppressed. The journalistic faculty permeated Mr. Forney's mind and for a time he obtained vent for his thoughts through various railroad and engineering publications, particularly the *Railroad Gazette.* This led him in 1870 into negotiations with the *Gazette* for a position on the staff and he was appointed associate editor, the paper being then published in Chicago. The great fire occurred there the following year and the headquarters of the *Railroad Gazette* were moved to New York, Mr. Forney having bought a half interest in the property. His work very quickly brought the *Railroad Gazette* to be recognized as the best authority in the world on railroad mechanical engineering. He began writing what is known as The Catechism of the Locomotive in 1873 and it was published in his paper in serial form and afterward put out in book form. It was rewritten ten years later, and the author was engaged rewriting it at the time of his death.

Besides his well-known locomotive, Mr. Forney was the inventor of many devices, mostly for railroad purposes. In the autobiography already referred to he says:

"Invention has always had a great fascination for me as it has many others. It is akin to the passion which the fatuity of gambling has to a gamester, and once having developed the taste for invention, its allurements have led me on, as will be shown by the following list of patents

which have been granted me." Then follows a list of thirty-three patents, most of them for improvements on the locomotive.

Matthias N. Forney was a fertile inventor and an accomplished designer of railroad appliances, but his fame well rests upon his work as an engineering journalist and author. Besides possessing the faculty of clear, lucid diction that was always comprehensible, Mr. Forney's writings always possessed a streak of humor that enhanced their charm. When Angus Sinclair was writing his book on the Development of the Locomotive Engine, he wrote asking Mr. Forney to send his portrait. In replying Mr. Forney wrote: "I have been waiting for several years past to get sufficiently good looking so as to have a better picture made. Since my long illness of last summer my friends tell me I am looking better, but, alas, none of them say I am better looking." When he sent a picture a few weeks later, he wrote: "The photographer struggled hard to make a handsome picture, but, as you will see, he did not succeed. The worst of it is that the picture looks like me."

As editor of the *Railroad Gazette* Mr. Forney never failed to tell the truth about the engineering heresies and humbugs that were coming to public notice periodically. The narrow gauge fallacy, the Fontaine locomotive idiocy and many other freaks had their day of popularity shortened by Mr. Forney's incisive analysis and scathing ridicule.

In 1883 Mr. Forney left the editorial chair of the *Railroad Gazette,* realizing that he was overworking himself. A few months before taking this step he asked Angus Sinclair to become his assistant, but that gentleman was working on another paper under a time engagement. Mr. Forney frequently said that if he had secured Mr. Sinclair as an assistant he would have remained with the *Gazette.*

Through his influence the Master Car Builders was reorganized and Mr. Forney became secretary, holding the position for several years. Three years after quitting the editorial chair, the allurements of journalism overpowered his senses and he bought the *American Railroad Journal* and *Van Nostrand Engineering Magazine,* consolidating them under the name of the *American Engineering and Railroad Journal.* That enterprise did not prove successful and he subsequently sold the property to Mr. R. M. Van Arsdale, who incorporated the paper with the *National Car and Locomotive Builder.*

Mr. Forney made some flights into the realms of politics, and published several books and pamphlets of a political character. But his great work is the Catechism of the Locomotive. That has been an instruction book for several generations of railroad men and will hold a high educational position as long as steam locomotives remain in use.

ANGUS SINCLAIR.

EDWARD RYAN.

Edward Ryan was born at Charlestown, Massachusetts, May 18, 1844, and died at Boston, April 6, 1908.

His early life was spent in Taunton, Massachusetts, where he obtained his education in the public schools. At the age of sixteen he entered service as an apprentice boilermaker and in that capacity worked on the "Nahant," which was built at the Atlantic Works in 1863 and was the first monitor built in East Boston. From the Atlantic Works he went to the James Tetlow Boiler and Iron Ship Building Works, completing his apprenticeship there. From 1865 to 1867 he worked at the Charleston Navy Yard, working on the "Niagara," "Connecticut," "Santiago de Cuba" "Monadnock," and other noted boats of that day. From 1865 to 1871 he was employed by the Roach Shipbuilding Works, Burnside Locomotive Works and other shops and railroads; from 1871 to 1874 as foreman of the Boston and Albany railroad shops; from 1874 to 1876 he was employed with the Central Pacific Ry.; 1878 to 1879 foreman Chicago & Paducah Ry.; 1879 to 1880 Houston & Texas Central R. R. In 1880 he went with the G. H. & S. A. Ry., was made foreman in 1881, general foreman in 1883 and master mechanic in 1895, which position he held at the time of his death. He became a member of this Association in 1893.

Mr. Ryan was an able man in his profession, of sterling character, upright and conscientious in all his dealings, and his demise is greatly regretted by his associates, subordinates, and all with whom he came in contact.

G. W. Butcher.

ORLANDO STEWART.

Mr. Orlando Stewart died in Boston April 27, 1908, at the age of seventy-five years. Practically his entire life from the age of fifteen up to within one year of his death was spent in railroad service, making nearly sixty years of continuous service. He was born at St. Albans, Maine, October 23, 1833, and at the age of fourteen served as an apprentice in the shops of the Boston and Maine R. R. He remained in this capacity until 1850 at which time he accepted a position as gang boss with the Erie Railroad Co.

In 1853 he accepted position of shop foreman with the Bellefontaine & Indiana Ry. This line is now a part of the C. C. C. & St. L. Ry.

In 1856 he commenced as engineer on the Boston & Lowell R. R. (now a part of the B. & M. R. R.), and remained with them until 1863, at which time he was appointed general foreman of the U. S. Government shops at Chattanooga, Tennessee, remaining in that capacity two years. He again resumed work as an engineer on the Boston & Lowell R. R. in 1866, remaining with them until 1878, at which time he was appointed foreman of the erecting shops of the Hinkley Locomotive Works at Boston. He remained with them three years, and in 1881 accepted a like position with the Rhode Island Locomotive Works at Providence, Rhode Island. He held this position for one year only, when he concluded to again engage in active railroad work, and he was appointed assistant master mechanic of the New York, Providence & Boston R. R. (now a part of the N. Y. N. H. & H. R. R.). This position he resigned in 1884 to accept the important position of superintendent of motive power of the Fitchburg R. R. (Now a part of the B. & M. R. R.).

He was with the above road for a long time, and in 1894 he accepted the position of Superintendent of Motive Power and Equipment of the Bangor & Aroostook R. R., with headquarters at Hartwell, Maine. He was located at Hartwell for ten years and then transferred to Milo Junction, Maine, where the new shops of the B. & A. R. R. are located. He held this position up to October 1, 1907, at which time he resigned on account of ill health. Mr. Stewart had been in poor health for a year prior to resigning from the service. Upon his retirement from railroad service he moved to Boston, Massachusetts, but his health did not improve, and the end came April 27, 1908.

Mr. Stewart was a high Mason, and also an Odd Fellow. He was an earnest and loyal citizen, highly respected by the officials and the employes.

He had been an active member of the Master Mechanics' Association since its organization, and was well and favorably known by all its members.

He leaves a widow, and one daughter (married), who reside in Boston.

Hugh Montgomery.

O. H. JACKSON.

O. H. Jackson was born at Shelby, Ohio, in the year 1845; after receiving a common school education, in 1861, he entered the service in what was known at that time as the Mad River shops as an apprentice, working in that capacity for several years, after which he identified himself with Kasson & Co. as a messenger, distributing new engines through the South. Subsequently, after serving as machinist at several points, he was employed in running locomotives on several different roads until 1876.

In 1883 he was employed as foreman in what was known as the N. Y. P. & O. R. R. shops at that time located at Galion, Ohio, leaving there in 1885 to resume running on the road. In 1890 he was employed as Master Mechanic on what was known at that time as the I. B. & W. R. R., now the P. & E. division of the Big Four; subsequently transferred to the Brightwood shops until 1893, he was afterward employed as General Master Mechanic of the Santa Fe, Prescott & Phoenix R. R. at Prescott, Arizona, remaining in that capacity for a period of six years, at which time he took charge of the mechanical department of the Indianapolis Union Ry., in which capacity he was serving at the time of his death on August 19, 1906. Mr. Jackson became a member of this Association in 1888.

WM. GARSTANG.

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